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Issued June 23, 1916.

HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge.

REPORT OF
THE HAWAII AGRICULTURAL
EXPERIMENT STATION.

1915.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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¹ Appointed July 25, 1915, to succeed Wm. T. McGeorge, transferred to U. S. Department of Agriculture, Bureau of Chemistry.

² Resigned June 30, 1915.

³ Appointed July 6, 1915, to succeed F. A. Clowes, resigned.

LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, September 14, 1915.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1915.

Respectfully,

J. M. WESTGATE,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

	Page.
Summary of investigations.....	9
Introduction.....	9
Buildings and grounds.....	9
Changes in the station staff.....	10
Territorial marketing division.....	10
Horticultural investigations.....	12
Entomological investigations.....	13
Chemical investigations.....	13
Agronomic investigations.....	14
Agricultural extension.....	15
Substations.....	16
Glenwood substation.....	17
Needs of the station.....	18
Publications.....	19
Report of the horticultural department.....	20
The extension of the litchi.....	20
The mango.....	21
Premature flowering.....	21
Bud mutation.....	22
Bark grafting.....	22
The avocado.....	23
Propagation experiments.....	24
Multiple-stemmed seedlings.....	24
The papaya.....	24
Citrus orchard.....	25
Wood oil and kukui.....	25
Distribution of seeds and plants.....	26
Extension work in horticulture.....	27
Needs of the horticultural department.....	27
Report of the entomological department.....	28
Report of the chemical department.....	29
Fixation of fertilizers.....	29
Bacteriological investigations.....	30
Physical studies of Hawaiian soils.....	30
Soil survey.....	31
The organic phosphoric acid of rice.....	31
The effect of arsenite of soda on the soil.....	32
The availability of phosphates.....	32
Legumes as green manure.....	32
The analysis of Hawaiian soils.....	33
Modification in analysis.....	34
Acid digestion.....	34

Report of the chemical department—Continued.

The analysis of Hawaiian soils—Continued.

Modification in analysis—Continued.

	Page.
Insoluble residue.....	34
Iron, aluminum, and titanium.....	34
Manganese.....	35
Calcium.....	35
Magnesium.....	35
Sulphates.....	36
Potash and soda.....	36
Phosphoric acid.....	36
Humus.....	36
Soil colloids.....	36
The effect of partial sterilization on plant growth.....	37
Onions.....	38
Millet.....	38
Cowpeas.....	38
Report of the agronomy department.....	39
Soil aeration tests with rice and taro.....	39
Potatoes.....	40
Legumes.....	40
Small grains.....	41
Sorghums.....	41
Grasses.....	42
Buckwheat.....	43
Japanese millet.....	43
Nut grass control.....	43
Cotton.....	44
Seed distribution.....	44
Report of the extension division.....	45
Inauguration of the work.....	45
Miscellaneous demonstrations.....	46
Demonstration farms.....	48
Cooperative experiments.....	49
Report of the Glenwood substation.....	51
Honohono (<i>Commelina nudiflora</i>).....	51
<i>Paspalum dilatatum</i> as a pasture grass.....	52
Cane-top silage.....	52
Cattle.....	53
Farming operations.....	54
Poultry.....	54
Extension work.....	56
Horticultural observations in Porto Rico, Cuba, and Florida in relation to the horticulture of Hawaii.....	58
The pineapple industry in Porto Rico.....	58
Cultural methods.....	59
Diseases and insects.....	61
Marketing.....	61
Canned pineapples.....	62
Pineapples in Cuba.....	64
Pineapples in Florida.....	64
Summary of output of fresh pineapples in countries visited.....	66
Citrus fruits.....	66
The avocado.....	70
The mango.....	72

ILLUSTRATIONS.

	Page.
PLATE I. Fig. 1.—Honolulu's oldest litchi tree. Fig. 2.—Mango seedlings in flower, less than nine months old.....	24
II. Fig. 1.—Bark grafting the mango. Fig. 2.—Scion budding applied to the avocado.....	24
III. Effect of partial sterilization of sandy soil on plant growth. Fig. 1.—Onions. Fig. 2.—Millet. Fig. 3.—Cowpeas.....	40
IV. Fig. 1.—Plat of Japanese millet on station grounds. Fig. 2.—Partial view of seed production tests of legumes valuable for green manure..	40
V. Fig. 1.—Beans and corn intercropped, pineapples in background, Haiku demonstration farm. Fig. 2.—Preparing ground in pineapple field for dynamiting, Haiku demonstrating farm.....	48
VI. Fig. 1.—Detailed view of honohono, a valuable soiling crop for dairy cattle, Glenwood substation. Fig. 2.—Silo and general view of the grounds of the Glenwood substation.....	48
VII. Fig. 1.—Citrus orchard with pineapple interplanting in Porto Rico. Fig. 2.—View in a 20-acre avocado orchard in Florida.....	64
VIII. Fig. 1.—A pineapple cannery near San Juan, Porto Rico. Fig. 2.—A bullock wagon delivering pineapples in bulk at the packing house in Cuba.....	64
IX. Fig. 1.—Crates of mangoes as they are packed in Florida. Fig. 2.—A tree top-worked to the Haden mango.....	72

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1915.

SUMMARY OF INVESTIGATIONS.

By J. M. WESTGATE, *Agronomist in Charge.*

INTRODUCTION.

The station has continued as in the past to aid in the development of diversified agricultural industries in the islands. There are a number of crops that have been found agriculturally possible which at present are not able to compete economically with sugar, and the station has continued its experimental and extension work to place some of these on a profitable basis. It is felt that the most stable prosperity is that which is based upon a number of lines of industry rather than upon a single crop. To this end the station is collecting data as to the agricultural possibilities of different crops on the different soils of the various islands. As rapidly as possible the cultural requirements of these various crops in relation to soils, altitudes, and moisture supply are being worked out.

BUILDINGS AND GROUNDS.

During the year only minor repairs and additions were made in connection with the station buildings. The roofs of three of the buildings were treated with roof-preserving paint in order to prolong the life of the shingles. The foundations of the same buildings were also repaired where decay and insect pests had weakened or destroyed the timbers. It was found necessary to rebuild one of the large water tanks holding a reserve water supply of 60,000 gallons.

The Marine-Hospital Service tract of land adjoining the station grounds was resurveyed and laid out in plats for the department of agronomy. The survey indicated that there were about 3 acres available for cultivated crops. This ground was replowed and planted to corn, potatoes, and various green-manure crops.

Owing to the unevenness of the soil as well as to the high cost of water for irrigating, especially for rice and taro, the lease of the Wyllie Street tract was terminated at the end of the year. Arrangements have been made with private rice and taro growers for co-operative experiments along the same lines as those carried out on this tract, and at considerably less expense to the station.

Preliminary arrangements were made with the officers in charge of the Army reservations for the lease of a tract of 10 acres of land for the purpose of determining the possibility of forage production for the Army horses. The rainfall is somewhat limited, but it is expected that proper methods of tillage and spacing will make possible economical yields of certain species of forage grasses.

CHANGES IN THE STATION STAFF.

During the year a considerable number of changes were made in the scientific staff of the station. On January 1, 1915, E. V. Wilcox, special agent in charge, was transferred to Washington, D. C., and was succeeded by J. M. Westgate, who was transferred from the Office of Forage Crop Investigations, United States Department of Agriculture. D. T. Fullaway, entomologist, returned from his year's furlough on June 1, 1915, but resigned June 30, 1915, to accept a position with the Territorial Board of Agriculture and Forestry in connection with the search for parasites of the melon fly (*Dacus cucurbitæ*). W. P. Kelley, chemist, resigned October 27, 1914, to become professor of agricultural chemistry in the Graduate School of Tropical Agriculture and Citrus Experiment Station at Riverside, Cal. He was succeeded by Wm. T. McGeorge, formerly assistant chemist at this station. Mr. McGeorge in turn left the station June 30, 1915, on a transfer to the Bureau of Chemistry, United States Department of Agriculture. Mr. McGeorge's transfer, however, did not become effective until July 8, 1915. F. A. Clowes, superintendent of Hawaii substations, resigned June 30, 1915, to take charge of the agricultural department of the Lahainaluna Industrial School, where he will be retained as a collaborator of this station in order that he may attend to the work done in cooperation with that institution. F. G. Krauss was appointed superintendent of extension work beginning November 1, 1914. Mr. Krauss was formerly agronomist of this station, but had resigned to become professor of agronomy at the College of Hawaii, which position he was filling at the time he was appointed to take charge of the extension work of this station. J. de C. Jerves was appointed collaborator January 1, 1915, at Homestead, Kauai; John E. Gamalielson, April 1, 1915, at Hilo, Hawaii; and John McCoy, May 1, 1915, at Kamuela, Hawaii, to assist in the extension work among the small farmers of those sections. George Copp was appointed collaborator January 1, 1915, at Waiakoa, Maui, but resigned June 30, 1915.

TERRITORIAL MARKETING DIVISION.

The Territorial legislature at its 1913 session appropriated funds for the maintenance of a marketing division for Hawaiian-grown

products and the station was given supervision of the project. Not a little of the satisfactory results of the work of the marketing division has been due to the loyal support of the local newspapers and other agencies and individuals interested in the upbuilding of the lesser agricultural industries of the islands.

During the year the division has made a large increase in the amount of produce handled, the sales amounting to \$69,182.50 against \$26,095.10 for the preceding year. The consignments which have been received have generally been in better condition than formerly, but there is yet much to be done in educating the shipper to pick, grade, and pack his products properly.

Practically all Hawaiian agricultural products except sugar have been handled by the division, most of them successfully. The onion crop harvested this year met a very poor market due to the large hold-over supply of 1914 mainland onions. Prices on the mainland were so low that it did not pay to ship our early Bermuda onions, but fresh pineapples, bananas, Maui beans, and a small shipment of copra have brought good returns.

The division has continued to publish and distribute to the producers of the Territory the Weekly Market Quotation Sheet. This sheet gives the current wholesale quotations on island products and keeps the farmer in touch with the condition of the market. This sheet is also published by most of the papers of the Territory. Growers generally do not realize the importance of keeping the division posted as to the amount of produce they have to send to market and when it may be expected to arrive, but there has been considerable improvement in the past few months. It is safe to say that the producer has received better prices since the division was established than ever before, whether he marketed his produce through the division or elsewhere.

Up to the present time the division has been seriously handicapped due to the poor facilities for handling such a large assortment of products as has been sent in for sale. With the appropriation of \$14,400 for a new building and equipment made by the last legislature and an appropriation of \$1,000 a month for the ensuing biennium for general expenses, most of the present difficulties should be overcome. The last legislature also filled a pressing need when it appropriated \$7,500 to be used as a revolving fund for buying seed and crates to be resold to the farmers and for making advances on consignments. This fund has made it possible for the division to supply the growers with crates in which to ship their pineapples to the mainland without requiring payment for the crates until returns are received for the fruit.

Due to the apparent overproduction of pineapples in Hawaii and the prospect of a large portion of the 1915 crop rotting in the field

for want of a purchaser at a price less than half the cost of production, the division opened a branch office in San Francisco to sell fresh pineapples and such other products as find a better market on the mainland than at home.

HORTICULTURAL INVESTIGATIONS.

Horticultural investigations have continued along lines similar to those of recent years.

The litchi (*Litchi chinensis*) has received considerable attention. The excellence of this fruit, its high price, and its apparent adaptability to Hawaii have commended it for further investigations. The high price of the fruit is due to the limited supply and its popularity, not only among the Chinese, who are most familiar with this fruit, but also among all classes of the population. One of the reasons for the limited supply lies in the slowness of the methods of propagation in vogue, while another cause may be found in the great tardiness of seedling trees in coming into bearing. Experiments are being conducted to facilitate more rapid propagation by asexual means in the hope of overcoming both of these difficulties. Considerable progress has been made along these lines.

Attention has also been given to the preservation of the fruit for short periods in refrigeration, and also to various methods of transporting the seeds, which, under ordinary conditions, retain their viability only a few days. No deterioration in appearance or flavor of the fruit has been noted during refrigeration for the short periods which were tried. Other experiments along these lines are necessary. It was found possible to ship the seeds by mail in sphagnum moss, seeds having been sent by this means from Honolulu to Florida, where they are reported to have arrived in excellent condition.

In the mango investigations some studies have been made of the flowers and of the technique of cross-pollination. Bark grafting has been applied to the mango with considerable success, thus adding one more means for the top-working of established mango trees with choice varieties. Some of the new varieties of mango are not only superior to the common strains, but are more resistant to the Mediterranean fruit fly.

Some observations have been made of the keeping qualities of the Macdonald variety of avocado. Fruits were kept in the horticultural laboratory for 16 days without any refrigeration, and at the end of this time were in a perfect state of preservation. Bark grafting was tested on the avocado, but proved not to be so successful as scion budding, which consists in the inserting of the scion in a T-shaped incision in the bark of a mature branch.

Further pollinations of the papaya have been made, and lines of close-breeding as well as cross-breeding have been started.

A number of experiments have been made in the cross-pollination of two species of *Aleurites*, *A. moluccana*, the ordinary kukui of Hawaii, and *A. fordii*, known as the Chinese wood-oil tree. There are 120 fruits set, which are the result of these crosses, unless it may prove that some of them represent parthenocarpic or parthenogenetic developments.

The distribution of seeds and plants has been continued, chiefly with the varieties that have been under investigation, such as hibiscus, papaya, citrus, mango, and avocado.

ENTOMOLOGICAL INVESTIGATIONS.

On account of the absence of the entomologist for 11 months of the year, but little station work along entomological lines was accomplished. The insect collection was maintained, however, and a number of requests for assistance in combating insect pests were complied with either by personal visits or by advice as to the best methods of procedure. It had been anticipated that the entomologist while on furlough to the Territorial Board of Agriculture and Forestry, would be able to locate effective parasites for the pink bollworm of the cotton plant, but it was deemed inexpedient to assign him to this particular problem. Studies concerning the life history of the pink bollworm of cotton were made by August Busck, of the Bureau of Entomology, United States Department of Agriculture. Mr. Busck was given use of the insectary and entomological laboratory to facilitate the prosecution of his investigations.

CHEMICAL INVESTIGATIONS.

The relative value of the different forms of phosphate fertilizers has been determined in a series of pot experiments with three types of Hawaiian soils. The crops used were Japanese millet, cowpeas, buckwheat, radishes, and turnips. The results indicate that bone meal or other difficultly soluble phosphates are of little value as fertilizers in most parts of the Hawaiian Islands, since the soil already contains a large quantity of insoluble phosphate. For the best returns the phosphoric acid should be used in the form of soluble phosphate and in light applications at frequent intervals. The insoluble phosphates are of little value except in the wet districts. In soils high in iron and alumina, lime has in the past been added with applications of soluble phosphates in order to delay the formation of iron and aluminum phosphates. It has been found, however, that plants fertilized with iron and aluminum phosphates have made very satisfactory growth.

Organic phosphorus in rice was found to be present in the form of phytin. Since the phytin occurs in unpolished rice and rice bran, but not in the polished rice, it is evident that the phytin is normally present only in the outer layers of the rice grain.

This station has been a persistent advocate of the use of legumes for green manuring for many years. Pot cultures have been made with 32 species of legumes. In one series of pots the entire plant has been turned under in order that the humus value and amount of nitrogen added may be determined. In the second series the nitrogen fixed by the plants has been determined. It was found that the nitrates in pots where legumes had been grown were much lower than in the check pot, but after removing the plant and allowing the pot to stand in the open the amount of nitrates soon equaled that in the check pots. Lime was found to be necessary for the best growth of the legumes.

Arsenite of soda has had quite an extensive use as a weed destroyer. In soil which had been sprayed with this chemical the arsenic was found to have accumulated in the top 4 inches of soil. The use of such sprays in excessive amounts should therefore be avoided.

The peculiar character of Hawaiian soils makes necessary some modifications of the ordinary methods of soil analysis. The experience in soil analysis on the part of the various chemists employed at this station has been summarized, and a modified method of analysis has been prepared and is given in the body of this report.

A bulletin of the station entitled "The Soils of the Hawaiian Islands"¹ gives the results of six years' work on Hawaiian soils, together with the practical application of the results obtained. Successful soil management requires deep plowing, followed by frequent shallow cultivations. Because of the heavy clay character of the soils and consequent danger of "puddling," the maintenance of the humus content by rotation of crops and green manuring is essential for the best results. Proper drainage is also important. In general, both nitrogen and phosphoric acid give good results as fertilizers. Soluble phosphates are recommended except in wet districts. Where there is a heavy rainfall the insoluble phosphates are best. Under similar conditions organic and ammoniacal nitrogen are better than the nitrate.

AGRONOMIC INVESTIGATIONS.

The principal crops experimented with during the year were rice, taro, corn, potatoes, cotton, millet, as well as various forage grasses and legumes. In a liming and fertilizer test the yield of shelled

¹ Hawaii Sta. Bul. 40 (1915).

corn was greatest on the plat receiving lime only, the same having been applied at the rate of 1,100 pounds per acre.

In an experiment to determine the effect of soil aeration on yields of rice it was found in the first experiment that 308 pounds more per acre was obtained from the aerated than from the nonaerated plat. The second test showed 680 pounds per acre in favor of aeration.

In a preliminary test for determining the effect of aeration on yields of taro the taro itself showed a slightly increased yield, while the "hulis" (offsets) showed a considerable increase on the aerated plat.

In a spraying test with Bordeaux mixture and lime sulphur for potato fungi on Early Rose potatoes the plat sprayed with Bordeaux produced at the rate of 30.2 bushels, as compared with 25.9 bushels for the lime-sulphur spray and 15 bushels per acre for the check.

In the tests of legumes for green manuring jack beans and velvet beans are among the most promising.

In an alfalfa yield test the ordinary alfalfas were found to out-yield both the Peruvian and Turkestan varieties.

The sorghums constitute a very promising class of green forage crops, some averaging as high as 15 tons per acre, with the cutting 90 to 100 days apart.

Of the forage grasses Sudan grass is easily the most promising for general use throughout the islands. The fondness of the birds for seed of this grass makes the problem of seed production a difficult one. The station plats are protected with bird-proof nets.

Interesting results were obtained from Japanese millet. Yields as high as 12 tons of green forage, 3 tons of roughage, and 30 bushels of seed per acre have been obtained. Plantings of this crop are most satisfactory when made in November and December and harvested in January and February, the time of year when sorghums are not making rapid growth.

Numerous distributions of seed from all the more promising grasses and leguminous forage crops, as well as other field crops, have been made to farmers having facilities for making tests and increasing the available seed supply of the particular species in question.

AGRICULTURAL EXTENSION.

The extension division was definitely organized in November, 1914, although considerable extension work had been in progress before that date. The work centers in part in the substations referred to elsewhere in this report and in part in the various extension activities, such as demonstration farm work, trips to various stations on

the part of extension workers, assistance at agricultural fairs, fostering of boys' and girls' agricultural clubs, together with field demonstrations of improved means of crop production on private farms under the general supervision of the extension agents. It is felt that a great deal of good has been accomplished as a result of the voluminous correspondence with persons who have written to the station asking for advice and information concerning their more pressing agricultural problems. One of the most serious problems in connection with the extension work is that of providing for the large amount of travel that appears to be necessary if the agents are to keep in touch with the various individuals they should reach. Travel by water to a number of places is possible only by boats that make the call at rather infrequent intervals. On land the distances between the different sections are often such as to make automobile service essential in the interests of time economy. The commercial charges are such as to make it impossible to use such service except in cases of extreme emergency. It is true that a great many individuals have their own automobiles and willingly place them at the disposal of the extension agents for the visit to their places. Those who most need the services of the extension division, however, are seldom in a position to provide transportation of any kind.

SUBSTATIONS.

Owing to the withdrawal of Territorial funds, it was found necessary to abandon the various substations with the exception of that at Glenwood, which was continued on a greatly decreased allotment, a part of which came from private subscriptions. The banana work at Hilo, however, was continued under the supervision of the superintendent of the Glenwood substation. The extension funds of the station have made possible the employment of several collaborators who devote portions of their own farms to demonstration work and use the results obtained as a basis in part for extension work among the farmers they are able to reach. Work of this kind is under way at Haiku, Maui; at Hilo, Hawaii; at Kamuela, Hawaii; and at Kalaheo homestead, Kauai. At Hilo the collaborator is chiefly concerned with the development of improved methods of butter making in order that the product may compete more successfully with butter imported from the mainland. At Kamuela a typical homestead is being conducted by the collaborator at that place. He is making a number of trials of various crops to determine which are economically practicable under the local conditions. For instance, it is found that, while a considerable number of fresh green vegetables can be produced, it does not seem profitable to ship

them to Honolulu, owing to the long haul to the wharf, the high freight rate, and the rough treatment often accorded such shipments because of the necessity of transferring the shipments from small boats to the steamers, which are unable to reach the wharf. It therefore seems advisable for homesteaders in such sections to raise pigs and poultry and such crops as can be marketed in a dry condition and in quantity. At Kalaheo homestead the collaborator has given considerable attention to the extension of the poultry industry throughout his immediate section. He has also become interested in the possibilities of starch production from cassava, and a number of his neighbors are planting considerable acreages. At the present time the starch is selling for 7 cents a pound. At Haiku both extension work and demonstration work are under way on a comparatively large scale, and a separate report of the work of this station, as well as of that at Glenwood, appears in this report.

This station maintains what is essentially a substation on the slopes of Mount Tantalus at an elevation of about 1,000 feet. The station reservation includes all the land between the Tantalus substation and the station plats at the lower end of the tract, but most of the intervening land is uncleared and in this condition is not suitable for experimental work. At the upper station there are under test and observation numerous species of plants which do not thrive at lower altitudes. The principal crops under test are bananas, coffee, rubber, avocado, Chinese wood-oil nuts, Macadamia nuts, citrus trees, and roselle.

GLENWOOD SUBSTATION.

The reduction of the Territorial allotment for the work of the Glenwood substation materially handicapped the work of the station during the entire year, only the bare maintenance and a few other essential expenditures being possible. In spite of this handicap, which necessitated material curtailments in its activities, much good has resulted from the continued operation of the station. The dairy herds of the entire section have been improved by the utilization of the herd bull, while the sale of eggs for hatching from the station poultry flocks has materially improved many of the flocks throughout the islands. The introduction of such grasses as *Paspalum dilatatum* and the demonstration of the best methods of utilizing the native honohono have been of much assistance to the small farmer, who is largely dependent upon his herd of live stock for a livelihood. In addition to the actual work of the substation itself, the superintendent has taken an active interest in a large number of agricultural activities concerning which his advice and assistance were sought and apparently much appreciated.

NEEDS OF THE STATION.

There are several pressing needs of the station to which it is desired to call attention. At the station itself the services of a plant pathologist are needed. There are a number of plant diseases which manifestly lessen the production of several of the island crops which would otherwise be much more profitable. Among these may be mentioned potato blight, late blight of celery, a banana disease of somewhat obscure nature, a root rot of taro, and several other diseases which are not conspicuous simply because the crops which they attack are not at present being grown to any considerable extent on account of economic conditions prevailing in the islands. It is highly desirable that as complete information as possible be obtained concerning the best methods of controlling such plant diseases as now stand in the way of extensive production of the crops affected.

Hawaii presents, within limited areas, a greater diversity of climatic and soil conditions than can be found in an area of the same size in any part of the mainland of the United States. Within 3 or 4 miles the rainfall may vary from a few inches to 10 or 12 feet per year. The changes in altitude on the rapidly ascending mountain slopes cause changes in temperature varying from strictly tropical to that of the region of frost and snow. This great diversity gives rise to regional limitations of adaptability. Pineapples, for example, prosper at certain altitudes where there is sufficient rainfall. Coffee likewise flourishes at certain altitudes and under certain conditions of soil and rainfall, but elsewhere is a failure. Hence it becomes necessary that many of the problems pertaining to crop production be worked out in the localities typical for each crop. It is important that there should now be a pineapple substation where the problems of this industry, second only to sugar cane in value, might be worked out.

As another particular instance it may be mentioned that at Schofield Barracks there is a great need of forage for the Cavalry horses and work mules. At present hay has to be brought from the mainland at large expense for freight alone. There is available on the reservation probably sufficient ground to grow all the roughage required when once the proper varieties and cultural requirements have been determined. It has therefore been recommended that a local substation be established on the tract in question where the practicability of growing suitable grasses or other forage can be definitely determined.

It is therefore recommended that as fast as funds will permit there be established substations in the sections where crop problems are most pressing, and where the potential importance of the crops in question is sufficient to justify such an expenditure.

PUBLICATIONS.

During the year the following publications were issued by the station:

Annual Report for 1914.

Bulletin 35, Absorption of Fertilizer Salts by Hawaiian Soils.

Bulletin 36, Grasses and Forage Plants of Hawaii.

Bulletin 37, Ammonification and Nitrification in Hawaiian Soils.

Bulletin 38, Effect of Fertilizers on the Physical Properties of Hawaiian Soils.

Press Bulletin 47, Cold Storage for Tropical Fruits.

Press Bulletin 48, Suppression of Weeds Among Pineapples by Arsenite of Soda Spray.

Press Bulletin 49, A Cheap and Effective Home-made Plank Drag.

Press Bulletin 50, The Effect of Arsenite of Soda on the Soil.

REPORT OF THE HORTICULTURAL DEPARTMENT.

By J. EDGAR HIGGINS.

The work of the horticultural department has been continued along lines similar to those of recent years. During the first part of the year the horticulturist was absent from the office, having reported for duty in Porto Rico at the close of a year's leave of absence. The latter part of June of the last fiscal year was spent in investigations of the fruit industries of Porto Rico, and the early part of the present fiscal year in travel in Cuba and Florida. The purposes of this travel were to observe horticultural conditions and progress in the countries visited with a view to the improvement of horticultural practices in Hawaii. The results of these investigations have been prepared for presentation in a separate report (see p. 58).

THE EXTENSION OF THE LITCHI.

The litchi, *Litchi chinensis* (*Nephelium litchi*), is now attracting considerable attention, not only in Hawaii (see Pl. I, fig. 1), but also in Florida and southern California. It appears probable that this fruit tree is adapted to a wider range of conditions than has been supposed. The excellence of the fruit and its very high price in Honolulu (60 to 75 cents a pound), due to the limited supply, makes it worthy of more attention. Considerable data have been accumulated during the year on methods of propagation, preservation of seeds, fruiting age, cultural methods, etc., which are being brought together in a separate paper. This station is cooperating in experiments in Florida and California with this species. A large number of seeds has been shipped to Florida in the pursuit of this work, and also as an experiment in transporting these short-lived seeds. About 50 pounds of fruit was shipped to the Office of Foreign Seed and Plant Introduction, in Washington, D. C., as a further means of testing the possibilities of the shipment of seeds and fruits. The shipment went in refrigeration as far as San Francisco and thence by ordinary express, icing being impossible with so small a quantity. The fruits are reported to have arrived in good condition.

On July 5 another small lot of fruit was placed in the fruit room of the United States Army transport *Thomas* at Honolulu en route for San Francisco. These were removed from refrigeration by the writer before arrival in San Francisco. They were in perfect pres-

ervation, apparently having lost nothing in flavor and appearance. Part of the seed was sent by mail in moist sphagnum moss to Washington, D. C., and part was distributed in localities of California, where it is hoped this species may succeed. All of this seed germinated well, demonstrating that it was not injured by refrigeration, and, further, that this is one of the means by which litchi seeds may be transported where refrigeration for fruit is available.

THE MANGO.

A number of interesting facts have been observed in the mango studies. Some preliminary studies have been made on the flowers of certain varieties and on methods of pollination. In the Alphonse variety, for example, it was found that a very large proportion of the flowers of the lower (inner) portion of the cluster was staminate. These staminate flowers have but one fertile stamen and four staminodes. They are unisexual by the abortion of the pistil, which sometimes may be detected in its aborted condition. These staminate flowers, while most abundant in the lower part of the lateral clusters, are also found throughout the entire cluster except near the outermost end of the central axis. The hermaphrodite or perfect flowers are found in all parts of the cluster, but chiefly near the termination of the lateral branches and of the central axis. At the base of the lateral clusters there are very few. These hermaphrodite flowers have but one stamen and one pistil, with four staminodes. The pistil is without any marked enlargement at the stigma.

The pollen of all the varieties of mango studied was found to be very small and almost colorless. In the few cross-pollinations which were made the ruptured anthers were brought into immediate contact with the flower being used as the female parent. This appeared to be a more practical means than any attempt to gather minute pollen grains and apply them with a brush.

PREMATURE FLOWERING.

Several mango seedlings less than 9 months old which had been grafted by inarching were found to be producing flower clusters above the point of union. In most cases the scion also was flowering, but in one case only the seedling stock. The mango tree ordinarily does not flower until it is from 5 to 6 years old, and the flowering of young seedlings less than a year old is quite beyond any observations that have been made here, and, so far as the writer is aware, no such cases have been previously recorded. Of 27 seedlings grafted to the Pirie, 4 produced flower clusters on the scions only, and 5 produced flowers on both seedlings and scions; of 5 grafted to the variety Brindabani, 1 produced flowers on the scion and on the seedling

stock, and 1 produced flowers on the seedling stock only, with none on the scion. That is to say, 18 per cent of the plants grafted to Pirie and 20 per cent of those grafted to Brindabani formed flowers on both scions and stock. There is, of course, nothing remarkable in the production of flowers on the scions. It is very common to find scions producing flowers from flower buds which have been matured on the tree before the removal of the scion, but flowers on seedling mango stocks less than 1 year old are worthy of note.

No cause can be ascribed for these phenomena except the grafting. It is true that the seedlings had been cut back slightly to induce growth in the scion, but this injury to the top of seedlings frequently occurs. Possibly the unusual results may be accounted for by the influence of the scion upon the stock, and it will be noted that in all cases save one the scions flowered as well as the stocks. In this one exception, the scion showed the scar of a flower cluster of the last season at its terminus. The mere mechanical injury brought about by grafting and the constriction resulting from the tightening of the raffia bands should also be taken into consideration. Plate I, figure 2, shows some of the trees referred to bearing their flowers.

BUD MUTATION.

Instances of bud mutation have not been commonly reported in the case of the mango. An instance apparently illustrating this phenomenon has recently received attention. Several trees grown from seed of the variety locally known as No. 9 have all produced fruits of the general type. A single branch of one of these trees, however, produced a pink fruit (the No. 9 is green), rather smaller in size than the regular type, but otherwise resembling the variety from which it was grown.

BARK GRAFTING.

The bark grafting of the mango, which has been successfully applied by the Porto Rico Experiment Station, has been tested under Hawaiian conditions during the year. It has proved to be well adapted to the work of top-grafting established trees and is one more method available in this work. One of the great advantages of the method is its extreme simplicity. Bark grafting, which has been so commonly used in Hawaii on hibiscus, consists in the cutting of a scion with one bearing surface and inserting the same under the bark of a branch which has been cut back for the purpose (Pl. II, fig. 1). Branches of the stock may be selected from 1 inch to 3 or 4 inches in diameter, at a time when the bark is slipping. This feature is extremely important, as it is also when budding the mango. This condition of the bark usually occurs when the terminal buds

are just beginning to burst open. A single straight slit about 5 inches long is made in the bark where the branch is cut off. The best scions are of rather small, well-matured wood of the last flush, and the end of the flush is preferable. Such scions are cut with one straight cut, giving a single bearing surface to be placed next to the cambium of the stock. The scion must then be securely tied in place with a strong tie, because the mango bark is thick, and if it begins to dry out it will break a weak strand. The whole scion and the top of the branch used as a stock must then be covered with a paper sack which has been dipped in warm wax. The sack is then tied close to the stock. This covering prevents excessive transpiration of moisture from the scion, which otherwise would be exhausted before a union could take place. The covering may be removed in about three weeks. From 50 to 75 per cent of the scions so inserted, under favorable conditions, may be expected to grow.

With this method available, as well as others which have been described in earlier reports and bulletins, there certainly is no good reason for continuing to allow vigorous trees to produce the worthless fruits which many now yield. The common Hawaiian mango is so inferior to some of the newer varieties that for this reason alone it should be largely replaced. The fact that the Hawaiian variety is so extremely subject to attacks of the Mediterranean fruit fly that few fruits escape, is a further reason for reducing the number of this variety and substituting the Pirie or other resistant varieties.

THE AVOCADO.

The avocado is one of the few fruits that is attacked by the fruit fly to so slight a degree that the injury is practically negligible from the standpoint of fruit production, although the pest has interfered with the marketing of this fruit on the mainland of the United States. Hawaii, however, has been of assistance to the mainland in the establishment of the avocado industry there, the results of most experimental work in Hawaii being of use in Florida and southern California. Many of the Hawaiian seedlings suffered severely in the frost of southern California in the winter of 1913. Some, however, the Nutmeg, for example, have shown considerable resistance to cold. Among the Hawaiian seedlings which are attracting attention in California are the Solano and the Meserve.

The Macdonald, the parent tree of many of the round, hard-shelled winter seedlings, has attracted some attention this year by its remarkable keeping qualities. Fruits were kept in the horticultural laboratory for 16 days without any refrigeration, and at the end of this time were in a perfect state of preservation. These winter fruits are most promising because of their season, and the hard-shelled character is greatly in their favor.

PROPAGATION EXPERIMENTS.

The method of bark grafting applied to the mango has also been tested on the avocado, but has not, up to the present time, proved satisfactory. Scion budding, however, which is quite similar in character, has given satisfactory results. This consists in inserting a scion in a T-shaped incision in the stock. The stocks used for this purpose have been from 1 inch to 4 inches in diameter. The T-shaped incision is made in the same manner as for shield budding, but is much larger. The scion consists preferably of a short piece at the end of a branch from a mature tree which is not growing too rapidly (Pl. II, fig. 2). This scion is prepared by a single cut, and is inserted in the incision, bringing one surface only into contact with the cambium of the stock. It is then tied in place and waxed with a firm grafting wax which will not run when heated by the sun.

This method of propagation appears to have two points in its favor. It affords a means of propagating from old bearing trees which frequently do not produce good bud wood unless they are severely cut back and forced to do so. Scions, however, may be taken from the terminals of slow-growing branches on which there is no material for ordinary shield budding. A further point in favor of the method is that it can be used to work into branches of considerable size, whereas for shield budding it would be necessary to cut back the stock and await the growth of new shoots in which to insert the buds. It is not intended to imply that this method is preferable to shield budding even for top-working trees, but that it may be rendered serviceable under certain conditions.

MULTIPLE-STEMMED SEEDLINGS.

It is a well-known fact that many avocado seeds send up numerous stems. It has been suggested that some of these might be the result of multiple germs. All the multiple-stemmed seedlings which have been studied up to the present time have indicated that there has been a single central stem and the others have arisen from buds on this stem beneath the surface of the ground and in many cases within the seed.

THE PAPAYA.

The work of the breeding of papayas was resumed along the lines indicated in earlier annual reports and in a bulletin of the station.¹ There are no conclusions of special moment to report at present. A number of crosses and close pollinations have been made to secure information on questions arising in earlier work. It is very interesting as well from a practical as from a scientific point of view to

¹ Hawaii Sta. Bul. 32 (1914).

247



FIG. 1.—HONOLULU'S OLDEST LITCHI TREE.



FIG. 2.—MANGO SEEDLINGS IN FLOWER, LESS THAN 9 MONTHS OLD.

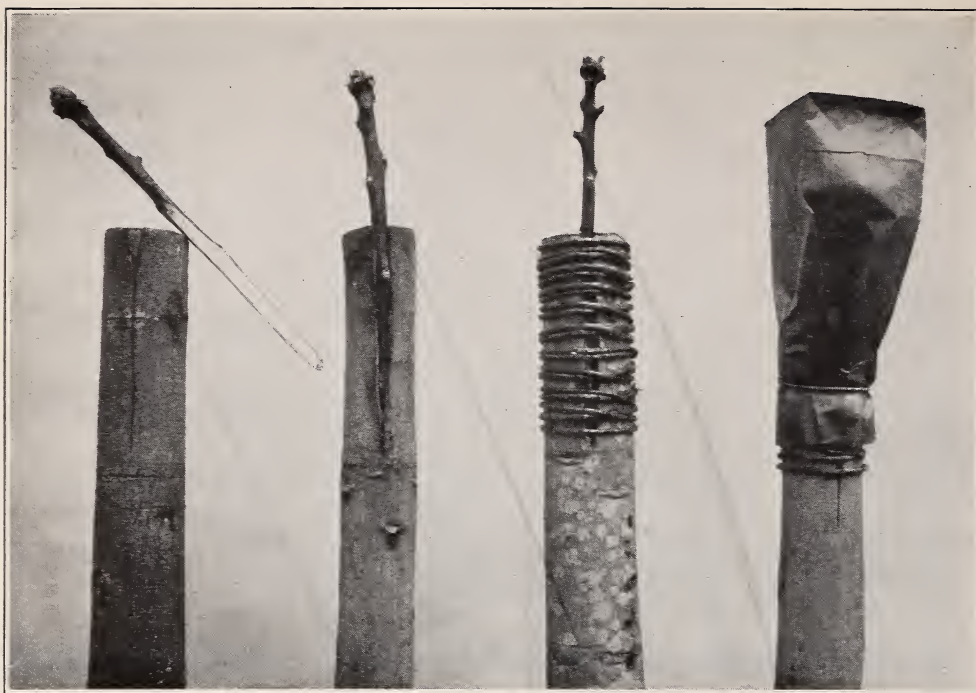


FIG. 1.—BARK GRAFTING THE MANGO.



FIG. 2.—SCION BUDDING APPLIED TO THE AVOCADO.

learn what are some of the factors determining sex in a species producing both dioecious and hermaphroditic stocks. Will the pollen from a hermaphrodite flower produce offspring that will be almost exclusively fruit bearing, either pistillate or hermaphrodite? To throw light on this and related questions, pollinations have been made as follows:

Flowers of pistillate trees of dioecious stocks have been fertilized with pollen from hermaphrodite flowers of the elongata form. Flowers of pistillate trees of the hermaphroditic stock have received pollen from staminate trees. Pistillate trees of dioecious stocks again have been fertilized with pollen from hermaphrodite flowers of the pentandria forms, both oval and pyriform. The possibility of perfecting such fertilizations had in most cases been determined in earlier experiments, but the sex of the progeny has not yet been observed.

A series of close pollinations also has been begun, wherein hermaphrodite flowers of elongata form have received their own pollen exclusively, the purpose being to initiate close breeding.

A number of cross-pollinations also has been made with a view to determining, if possible, and combining unit characters pertaining to flavor, keeping qualities, uniformity in shape, and bearing habits.

CITRUS ORCHARD.

In the citrus orchard many varieties are now in bearing and making a satisfactory growth. Practically all these varieties have been introduced as bud wood and have been worked upon home-grown stocks, thus building up a supply of all the leading varieties of orange, lemon, lime, and grapefruit. A limited amount of bud wood of the following varieties, now bearing, is available: Oranges—Bahia, Bouquet des Fleurs, Golden Buckeye, Golden Nugget, Mediterranean Sweet, Navelencia, Ruby, Scented, Thompson, Valencia, Dancy, King, Willowleaved, and Satsuma; pomelos—Duncan, Imperial, Marsh, McCarty, Royal, and Triumph; lemons—Eureka, Genoa, Lisbon, Ponderosa, and Villafranca; and limes—Kusaie and Tahiti.

WOOD OIL AND KUKUI.

The commercial possibilities of the oil of kukui, *Aleurites moluccana* (*A. triloba*), and of the China wood oil, *Aleurites fordii* (*A. cordata*), have recently attracted considerable attention. It is claimed by some manufacturers that a blend of these two oils is preferable to either. It has been suggested that the hybridizing of these species might result in new forms that might combine the desired characters in a way superior to either of the parents. In bear-

ing habits the China wood-oil tree appears to be quite inferior to the kukui, which bears in clusters, while the Chinese tree produces usually only one nut at the end of each branch, where there is ordinarily found one pistillate flower surrounded by several staminate flowers.

Mr. Valentine S. Holt, assistant horticulturist, was requested to attempt the hybridizing of these species. From 37 cross-pollinations, in which *A. fordii* was used as the female parent, 26 fruits are now set. On *A. moluccana* there are 94 fruits, the flowers of which received pollen from *A. fordii* only. In neither case has it yet been proved that parthenocarpic or parthenogenetic development does not occur in these species, but it appears probable that there is an affinity between them which may be utilized in hybridization.

DISTRIBUTION OF SEEDS AND PLANTS.

A large number of valuable grafted and budded fruit trees have been distributed to different parts of the Territory, and some have been sent to the mainland and to foreign countries. These have consisted chiefly of mango and avocado, with a few lemons, limes, oranges, and grapefruit. Except in case of exchange, it has been the custom to make a charge for these to cover in part the cost of propagation and handling. By reason of a recent act of Congress, all money now received from sales of products reverts to the Treasury of the United States and does not become available for the use of the experiment station. It thus becomes impossible to recover expenditures made in propagation. For this reason and because other funds are not available, it will be necessary largely to discontinue this work, except as it relates to the introduction and establishing of new and unusual varieties.

The same applies even more strongly to the distribution of hibiscus cuttings. The new varieties of these ornamentals which have been originated here have been distributed in numbers aggregating hundreds of thousands at a nominal charge and may now be seen in all parts of the Territory, while they add to the beauty of many tropical lands. These flowers of rare and delicate beauty will be an asset to the Territory far exceeding all that they have cost. The time has come, however, when the future distribution of the plants and cuttings should be put on a commercial basis.

It has become necessary greatly to reduce the number of hibiscus plants at the experiment station, the land, and more particularly the water, being required for other plants. One plant of each of about 500 or 600 varieties, however, will be retained, while the others will be placed along the public highway at Army posts and public parks where they will benefit the largest number of observers.

Papaya seeds of the varieties bred here have been distributed to a large number of applicants. This will be continued in conjunction with the breeding work.

Seeds of various other economic plants have been distributed, among which may be mentioned roselle, *Carissa grandiflora*, Annonas, Carambolas, and star apples.

Bud wood of citrus varieties has also been sent wherever it has been requested.

EXTENSION WORK IN HORTICULTURE.

The knowledge of budding and grafting is not so general here as in countries where there is large commercial orcharding. Through various methods of extension work, the art is being taught which will make of more service the large collection of varieties at the station. Assistance was given by instruction and demonstration at the summer school for teachers. A trip was made by the horticulturist to the island of Maui, chiefly in the interest of this work. Another trip was made to Hilo to assist in the county fair. The horticulturist is now acting in an advisory capacity in connection with the present effort of the Territorial marketing division to place Hawaiian pineapples in the mainland markets in much larger quantities than heretofore, and thus relieve the situation of the growers who are unable to dispose of their crop.

NEEDS OF THE HORTICULTURAL DEPARTMENT.

The greatest needs of the horticultural department of this station at present are land and other facilities for culture experiments with pineapples and bananas. These are the two fruits of commercial importance for export, and at present they are the only fruits that are allowed entrance from Hawaii to the mainland markets. There is great need for field experiments with both of these crops, but none of the land at the experiment station furnishes normal conditions for them. It is hoped that funds may be made available for the leasing of a suitable tract of land upon which to begin this work.

REPORT OF THE ENTOMOLOGICAL DEPARTMENT.

By D. T. FULLAWAY.

The entomologist of the station was absent on leave from July 1, 1914, to May 31, 1915. During this time he was in the employ of the Territorial Board of Agriculture and Forestry, being engaged in the prosecution of the general campaign development of parasites of the Mediterranean fruit fly, a work which has met with considerable success.

The close proximity of these two stations to one another made it possible for the entomologist to keep his office open at the Federal experiment station and to attend to his routine work of correspondence and maintenance of the insect collection, which was greatly increased by material obtained from abroad.

During the month of June, 1915, most of the entomologist's time was spent in studies in connection with *Sierola* spp., the natural parasites of various species of Lepidoptera.

While the repeated absences of the entomologist from the station in connection with the Territory-wide insect parasite campaign has to some extent interfered with the work of independent investigation, it is believed, however, in view of what has been accomplished, that the agricultural interests of the islands have been better served than they would have been had the entomologist remained at the station engaged in individual work with parasites of the insect enemies of the agricultural and horticultural crops, or in other lines of entomological activity.

REPORT OF THE CHEMICAL DEPARTMENT.

By WM. T. McGEORGE.

During the past fiscal year Dr. W. P. Kelley resigned as head of the department to become professor of agricultural chemistry at the Graduate School of Tropical Agriculture and Citrus Experiment Station at Riverside, Cal. The work of the chemical department has proceeded with little interruption along the same lines as outlined in previous reports.

The investigation of scientific soil problems, having a very practical significance in the islands, has received the continuous attention of the staff, while all miscellaneous routine analyses have been made with as little interruption of the above work as possible. Marked progress has been made toward a thorough understanding of the peculiar properties, both physical and chemical, of Hawaiian soils.

FIXATION OF FERTILIZERS.

During the fiscal year 1914 experiments on the fixing power of Hawaiian soils were completed, and the results were issued during the past year as a bulletin of the station.¹

Due to the highly basic character of these island soils, the fixation of phosphoric acid is much higher than that of the other elements. The results show that the best method of application of the phosphates is just before planting. The soluble form should ordinarily be used.

The fixation of potash is apparently controlled by the amounts of lime and magnesia present, and is quite marked. Some loss by leaching is possible, however, if the potash is applied in too large quantities.

With ammonia nitrogen, while the point of saturation is higher, the fixation is not so strong as that of potash. Soils rich in humus retain the ammonia and also the potash better than the red clay type. This is probably due to interaction with the complex "humates."

The Hawaiian soils retain little, if any, of the nitrogen in the form of nitrate. Some highly organic soils, however, react with and fix some of the nitrate solution. Air drying, heat, and the use of anti-septics have little influence on the fixing power of the soil.

¹ Hawaii Sta. Bul. 35.

BACTERIOLOGICAL INVESTIGATIONS.

The results obtained by Dr. Kelley in the study of bacterial action in Hawaiian soils were published during the year as a bulletin of the station.¹

Due to the unusual character of the Hawaiian soils, the decomposition of organic nitrogen compounds into forms available for plant food is of considerable importance. The lime-magnesia ratio as influencing nitrification being a subject of much controversy, an investigation was made of the effect of magnesia on nitrification.

Observations show that nitrification does not take place in most Hawaiian soils unless oxidizing conditions are maintained by tillage. Besides aeration, virgin soils also require weathering for several months before the nitrifying bacteria will become active.

The effect of heat and antiseptics was also investigated. Partial sterilization probably makes available, through alterations in the colloidal film, new stores of food and organic material to the surviving organisms, and thus stimulates bacterial action. The effect of aeration also is partly due to the same cause assisted by granulation and oxidation.

The lime-magnesia ratio does not seem to be of much importance in Hawaiian soils. Magnesium carbonate favored ammonification, while calcium carbonate stimulated nitrification in some instances. Dolomitic and calcareous limestone will probably produce similar effects on the availability of the nitrogen in Hawaiian soils.

For any system of permanent agriculture on Hawaiian soils, rotation of crops, including green manuring, must be strongly insisted upon in order to maintain the best aeration possible.

PHYSICAL STUDIES OF HAWAIIAN SOILS.

In another bulletin issued during the year,² the results are given of an extensive study of the physical properties of Hawaiian soils and the effect of fertilizers on these properties. Since it is impossible to measure by chemical analysis the presence of a normal application of fertilizer in the soil, and since it has been shown that the addition of salts and fertilizing materials affects the structure of the soil materially, it is suggested that these measurements of the physical effects of applications of fertilizer would be of considerable importance in determining the value of the fertilizer salts.

In most instances the fertilizer salts increase hygroscopic moisture, lower vapor pressure, and increase the cohesion of the soil particles. Capillarity is diminished in clay soils but increased in sandy soils by the addition of salts. Fertilizers increase the resistance to percolation, which takes place most rapidly in sandy soils.

¹ Hawaii Sta. Bul. 37.

² Hawaii Sta. Bul. 38.

SOIL SURVEY.

Previous to the resignation of Dr. Kelley, a paper entitled "The Soils of the Hawaiian Islands" was prepared and submitted for publication as a bulletin of the station.¹ In this bulletin the work of about six years' investigation upon Hawaiian soils is taken up, dealing with the composition of the various types of soil found on the islands and the practical bearing and application of the various scientific investigations which have been carried on in this laboratory.

THE ORGANIC PHOSPHORIC ACID OF RICE.

It has been known for some years that phosphoric acid exists in grains in organic combination with inosite and some base, and, as such, is taken into the animal system as a supply of phosphoric acid to the body. Because of its physiological value, the organic phosphoric acid which is known as phytin or phytic acid has received considerable attention, and a number of investigators have studied its composition and occurrence in grains.

It was believed that a study of phytin in rice would be of interest, since rice is one of the principal crops raised in Hawaii, and is valued as food by many of the inhabitants. The isolation and study of the composition of the phytin in rice was made by Miss Alice R. Thompson, assistant chemist, and the detailed results have been published elsewhere.² It was found that most of the phytin in rice exists in the outer layer of the grains, and in the process of polishing the rice practically all the phytin is removed. Phytin was isolated from unpolished rice and from bran, but none could be obtained from polished rice. The total phosphorus was determined in the samples and found to be 2.29 per cent in the rice bran, 0.321 per cent in unpolished rice, and 0.140 per cent in polished rice.

The phytin was obtained by treating the sample bran and unpolished rice with 0.2 per cent hydrochloric acid and precipitating with barium hydroxid. The white barium salt was washed, dissolved, and reprecipitated several times with barium chlorid and alcohol. The composition of two samples of the tribarium salt was determined and the barium, phosphorus, carbon, and hydrogen contents compared with that of the tribarium-inosite-hexaphosphate salt reported by Anderson in other grains.

Special attention was paid to several methods of determining barium in the salt, and precautions were noted to be observed in obtaining a pure barium sulphate precipitate from solutions of the salt.

¹ Hawaii Sta. Bul. 40 (1915).

² U. S. Dept. Agr., Jour. Agr. Research, 3 (1915), No. 5, pp. 425-430.

Inosite was insolated from the barium phytate and its melting point determined.

THE EFFECT OF ARSENITE OF SODA ON THE SOIL.

The increased use of arsenite of soda spray as a means of killing weeds led to a study of the injurious effect of this chemical. Attention was given to its influence upon plant growth, on the biological and physical properties of the soil, and its chemical action toward the soil constituents. The soils studied were found to have a very strong fixing power for arsenic. A sample of soil from Nahiku, Maui, on which weeds had been sprayed for five years at the rate of three sprayings per year (5 pounds arsenic per acre per application) showed on analysis that all the arsenic was held in the top 4 inches of soil. Accounts of this work have been published.¹

THE AVAILABILITY OF PHOSPHATES.

This work, also mentioned in the last annual report, has been completed and submitted for publication as a bulletin of this station. It was broadened considerably more than was at first anticipated in order to study phosphates more thoroughly from all angles. The availability of all the commercial phosphates was compared; the solubility of phosphates naturally occurring in Hawaiian soils was studied; the fixation of phosphoric acid by the soil received some attention; and, finally, as an appendix, a modified method for determining phosphoric acid in local soils was submitted. The latter method was adopted after nearly 250 phosphate determinations.

The importance of the above work is realized when it is known that the phosphate content of Hawaiian soils is, with rare exceptions, ample for good plant growth, but owing to its extremely unavailable condition the addition of this type of plant food as a fertilizer is often desirable.

LEGUMES AS GREEN MANURE.

This station has consistently advocated the use of legumes as a green manure. The benefit derived from legumes is due to both chemical and physical effects on the soil; the nitrogen content is increased and the texture of the soil is improved by the added humus. The red clay Hawaiian soils, especially, need green manure to prevent puddling and to aid aeration.

In order to determine the relative value of the various legumes, pot experiments were made by Miss Alice R. Thompson, assistant

¹ Hawaii Sta. Press Bul. 50 (1915); U. S. Dept. Agr., Jour. Agr. Research, 5 (1915), No. 11, 459-463.

chemist. One hundred and thirty-two pots were filled with a calcareous soil and the same number with a lime-poor soil. Thirty-two varieties of legumes were grown, one variety being apportioned to four pots of each soil type. Four pots of each soil were thus left as checks. At maturity the duplicate plants in two of the four pots were removed, weighed, and the nitrogen determined. Nitrates, nitrites, ammonia, and total nitrogen were determined in the soil and compared with the check pots, after deducting the nitrogen added in the legume seed. Two pots were left of each variety of legume planted, the plants being turned under to decompose. The quantity of nitrogen added to the soil will be determined later.

In all instances the nitrates in the soil from which the legumes had been removed was much lower than in the check soil. But these soils low in nitrates on standing in the open air soon equaled in nitrate value the soil of the check pots. Where much legume material was turned under the nitrates in the soils were greatly increased.

The plants grown in soils deficient in lime made a poor growth and had a lower nitrogen content, calculated on a water-free basis, than the plants grown in soils rich in lime. In a second experiment lime was added to the lime-poor soil, but the plants grown in this soil were also undersized and low in nitrogen. In a third experiment phosphate fertilizer was added to the lime soil and plants again grown in these pots. Results are to be obtained in a few months from the last series.

THE ANALYSIS OF HAWAIIAN SOILS.

In the course of the examination of about 600 soil samples in this laboratory peculiarities in soil types have been met which necessitated slight modification in the method of soil analysis as outlined by the Association of Official Agricultural Chemists. Chief among the inhibiting factors may be mentioned the high content of iron, aluminum, titanium, and manganese.

The modifications found to produce best results are submitted herewith, as are also some data showing the influence of time upon the solvent properties of hydrochloric acid. It was hoped that, in view of the low silica content, the time of digestion could be shortened to advantage without lowering the thoroughness of the extraction.

Four soils were chosen for this work—a sandy soil (No. 1), a red clay (No. 2), a silty soil of high humus content (No. 3), and a brown clay (No. 4). These soils were digested on the steam bath with hydrochloric acid (specific gravity, 1.115) for 1, 4, 6, 8, 10, and 15 hour periods. The results are given in the table following.

Effect of time of digestion of soil in hydrochloric acid (specific gravity, 1.115) on thoroughness of extraction.

Soil No.	Time.	Insoluble residue.	Iron oxid.	Alumina.	Titanic oxid.	Manganomanganic oxid.	Lime.	Magnesium oxid.	Potash.	Sulphur trioxid.	Phosphoric acid.
	Hrs.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1.....	1	45.30	15.04	9.64	1.36	0.22	3.39	8.74	0.19	0.26	1.09
	4	48.12	16.44	9.21	1.41	.30	3.09	-----	.58	.21	.90
	6	38.06	16.36	14.79	1.61	.17	3.09	10.60	.62	.22	1.05
	8	37.10	16.80	14.44	1.71	.23	3.27	11.50	.72	.25	.96
	10	37.98	16.94	13.53	1.76	.17	3.58	10.50	.82	.35	.99
3.....	15	37.61	17.80	13.33	1.76	.18	3.21	11.10	.75	.32	.99
	1	37.24	9.08	10.90	1.07	.12	3.52	.91	.62	.35	2.35
	4	34.83	9.20	13.89	1.07	.11	4.00	1.02	.45	.34	2.31
	6	34.41	9.72	14.51	1.12	.12	3.76	.97	.41	.32	2.28
	8	34.15	9.44	14.91	1.12	.12	3.69	1.03	.52	.38	2.39
2.....	10	34.30	9.88	14.73	1.12	.20	4.14	1.11	.58	.35	2.29
	15	34.38	9.72	14.55	1.07	.13	3.90	1.02	.59	.38	2.26
	1	45.05	14.92	12.35	.78	3.03	.52	.28	-----	.26	.27
	4	35.58	16.16	20.83	.97	2.81	.54	.32	.26	.27	.37
	6	32.90	15.36	24.03	1.02	2.89	.52	.34	.38	.23	.32
4.....	8	31.88	16.08	25.25	1.02	2.48	.58	.58	.44	.26	.44
	10	30.89	16.52	25.94	1.07	2.53	.65	.57	.43	.29	.42
	15	29.93	17.40	25.01	1.07	2.63	.63	.59	.53	.28	.50
	1	46.10	24.64	10.67	3.12	.04	.26	.74	.11	.19	.53
	4	38.77	29.92	11.48	3.90	.04	.30	1.05	.16	.22	.43
4.....	6	34.59	30.00	11.96	4.19	.04	.30	.94	.20	.21	.40
	8	35.89	32.64	11.72	4.19	.07	.42	1.23	.23	.24	.36
	10	35.88	30.44	13.34	4.19	.08	.36	1.21	.22	.22	.50
	15	35.05	31.60	13.07	4.19	.04	.41	1.30	.26	.26	.51

As previously mentioned, it was hoped that a reduction in the time of digestion could be made for local conditions, but apparently best results are obtained by digesting for 10 hours. However, the conclusion is plainly evident that the use of hydrochloric acid of this strength is primarily a study of solution and not of ultimate composition, when applied to Hawaiian soils. A digestion of 10 hours by no means results in a complete extraction in all soils.

MODIFICATION IN ANALYSIS.

ACID DIGESTION.

Digest 10 grams of soil for 10 hours in a 300-cubic centimeter soil digestion flask with 100 cubic centimeters of hydrochloric acid (specific gravity, 1.115) in boiling water. Dilute with 50 cubic centimeters of water, filter while hot into a 500 cubic centimeter volumetric flask, and wash the residue until the filtrate is nearly 500 cubic centimeters. Cool to room temperature and make to volume (solution A).

INSOLUBLE RESIDUE.

Dry the insoluble residue and ignite to constant weight.

IRON, ALUMINUM, AND TITANIUM.

Take 50 cubic centimeters of solution A, add a few drops of nitric acid, boil for a few minutes, remove from hot plate, make

slightly alkaline with ammonia, and boil off the excess. Filter, wash several times with hot water, and transfer the precipitate and filter to the original beaker. Dissolve by boiling in dilute hydrochloric acid. Reprecipitate as before, filter, and wash free of chlorid. Dry, ignite, and weigh the precipitate as ferric oxid, alumina, titanium oxid, and phosphorus pentoxid. Reserve the filtrate (solution B) for determining manganese, calcium, and magnesium.

Treat a second aliquot of 50 cubic centimeters of solution A in the same way up to the point of ignition of the ammonia precipitate. Instead of igniting, transfer the precipitate to the original beaker and dissolve by boiling in dilute sulphuric acid. Transfer to a 100-cubic centimeter volumetric flask, cool, and make to volume. Determine the iron by titrating 25 cubic centimeters of this solution with tenth-normal potassium permanganate in the regular way. Determine titanium by the colorimetric method as follows: Transfer 5 cubic centimeters of the sulphuric-acid solution to a 50-cubic centimeter Nessler tube, dilute, and add 5 cubic centimeters of dilute sulphuric acid, 5 cubic centimeters of hydrogen peroxid, mix well, and compare with a standard prepared at the same time from a solution of titanium sulphate. The filtrate from the second aliquot should be reserved for the determination of sulphate, soda, and potash (solution C).

Since potassium permanganate oxidizes titanium as well as ferrous iron, it is necessary to calculate the volume of permanganate required to oxidize the titanium present and to make a correction accordingly in calculating the iron. The aluminum is determined as usual by difference.

MANGANESE.

Concentrate solution B to about 150 cubic centimeters, add about 3 cubic centimeters bromin (undiluted), allow to stand 5 minutes, add an excess of ammonium hydrate, and heat to boiling. Let stand overnight, filter, wash with hot water, dry, ignite, and weigh as mangano-manganic oxid (Mn_3O_4).

CALCIUM.

Evaporate the filtrate to dryness and drive off the ammonium salts. Dissolve the residue in dilute hydrochloric acid and determine calcium in the regular way. The removal of the large excess of ammonium salts is necessary in order that any unprecipitated manganese will be thrown down.

MAGNESIUM.

Magnesium may be determined by precipitation in the regular way from the above filtrate direct.

SULPHATES.

Best results have been obtained by removing the iron and aluminum previous to the precipitation of the sulphate. Hence, solution C is evaporated to dryness, ammonium salts volatilized, the residue dissolved in dilute hydrochloric acid, and the sulphate determined in the regular way with barium chlorid.

POTASH AND SODA.

From this point the analysis may be carried out on the above filtrate according to the official methods without modification.

PHOSPHORIC ACID.

To 50 cubic centimeters of solution A add a few drops of nitric acid and heat to boiling. Make alkaline with ammonium hydrate, boil off excess, filter, and wash. Transfer filter and contents to a beaker and boil with dilute nitric acid, nearly neutralize with ammonia, add 50 cubic centimeters of molybdate mixture with constant stirring, and allow to stand in water bath for four hours at 55° C. From this point proceed as in the official method.

HUMUS.

Modifications in the method of determining humus are dealt with in full in a press bulletin of this station.¹

SOIL COLLOIDS.

Frequent mention has been made in previous publications of this station of the presence of colloids in Hawaiian soils. A condition which apparently arises through the formation of this class of bodies was given some attention during the past year.

The clay soils may be divided into two classes: Class 1, in which the alumina is higher than the iron and the titanium is very low; and class 2, in which the alumina is lower than the iron and the titanium is high. The former class is the one showing the more colloidal properties, and in spite of this contains fewer clay particles than the latter class. In the analysis of the hydrochloric-acid extract, considerable difficulty arises upon filtering the ammonia precipitate of iron, aluminum, and titanate hydrates and phosphates. The inhibiting factor presents itself in the form of a colloidal gel, rendering the washing of the ammonia precipitate extremely difficult. This gel is insoluble in cold acids, and hence in redissolving the precipitate it is necessary to boil it in an acid solution.

¹ Hawaii Sta. Press Bul. 33.

A sample of this colloidal gel was analyzed with the following results:

	Per cent.
Silica (SiO_2)-----	1.04
Phosphoric acid (P_2O_5)-----	1.02
Manganomanganic oxid (Mn_3O_4)-----	.73
Titanic oxid (TiO_2)-----	.66
Ferric oxid (Fe_2O_3)-----	9.37
Aluminum oxid (Al_2O_3)-----	87.18

Apparently this colloid is aluminum hydroxid, the physical properties of which are influenced by a small amount of silica and titanium. In all soils which contain iron in excess of alumina, this colloidal gel is never formed, but in soils of high aluminum content it is invariably present.

THE EFFECT OF PARTIAL STERILIZATION ON PLANT GROWTH.

Considerable study has been devoted to the effect of partial sterilization upon Hawaiian soils. A previous publication¹ treats of the effect of heat upon the physical and chemical properties of the soil, while the biological influences are thoroughly dealt with in the bulletin referred to on page 30.

During the year the above work has been supplemented by pot experiments. Heretofore the influence of sterilization on plant growth has been demonstrated in an experimental way in Hawaii only in districts where brush, accumulated in clearing land, has been burned upon the soil. In these cases a remarkable influence upon plant growth has been noted.

The pot experiments were carried out as follows: Two types of soil were used, a red clay and a sandy soil high in organic matter. These soils were treated as follows: Heated in sunlight, in an oven at 80° , 110° , and 165° C., and in an autoclave at 10 pounds pressure. Those heated in the oven were left for 2 hours, that in the autoclave for only 1 hour. In addition soils were treated with the following antiseptics at the rate of 10 cubic centimeters per kilogram: Carbon bisulphid, chloroform, and toluene. Also a check was run with the above in which the soil fresh from the field, that is, undried in the air, was used. These pots were planted in duplicate to onions, millet, and cowpeas.

The influence upon plant growth is well shown in the accompanying illustration. (See Pl. III.) The plants as shown are three months old.

The above illustrations represent plant growth upon the sandy soil. The results upon the red clay soil, while different in certain instances,

¹ Hawaii Sta. Bul. 30 (1913).

as a whole are very much the same. A very poor stand was obtained in all the pots of red clay soil, for which reason no illustrations are submitted.

ONIONS.

The influence of partial sterilization upon onions was very marked. Volatile antiseptics produced a wonderful increase, while heating in the autoclave was productive of a substance evidently toxic toward this plant. (See Pl. III, fig. 1.)

MILLET.

An increase in vigor of the millet plant was correlated with an increase in temperature at which the soil was sterilized. The plants are more vigorous in the pots sterilized by heat than those sterilized by antiseptics. It appears that the organic substance having a toxic influence upon onions is without effect upon millet, for in the pot heated in the autoclave, the plants are as vigorous as any others. (See Pl. III, fig. 2.)

COWPEAS.

In case of cowpeas, the increase in temperature at which the soils were sterilized resulted in a steady decrease in vigor. While the volatile antiseptics lowered the vigor to a slight extent, their influence is not so marked as heat. These results clearly show the intimate relationship between leguminous plants and bacterial life in the soil. (See Pl. III, fig. 3.)

REPORT OF THE AGRONOMY DEPARTMENT.

By C. A. SAHR.

The work of this department consisted largely in the continuation of the lines followed in previous years. The unusually long droughts handicapped the agronomic work on fields not provided with irrigation facilities.

Repeated failures with both sweet and field corn on the station grounds clearly demonstrated the necessity of an adequate irrigation system to insure this crop against irregular seasons when grown outside of the corn belt of the islands. While many insects attack corn, the damage they do is nominal if the plant is grown under favorable conditions. As soon as the crop becomes checked in growth by drought and the whipping action of heavy winds, insect attacks render the crop unprofitable even as silage.

A fertilizer and rotation test with Reid Yellow Dent corn No. 901 was begun, the crop being planted October 1, 1914, and harvested January 9, 1915. The results were so contradictory that no generalizations can be made from them.

SOIL AERATION TESTS WITH RICE AND TARO.

Experiments to ascertain the effects of soil aeration between crops upon the actual yields of submerged crops were conducted with rice and taro.¹

The plat under test was divided, one-half being given a deep plowing early in June to allow aeration of the soil until the time of planting, while the remaining half or check plat was left untouched until plowed September 2. Both plats were planted to rice September 4, 1914, and the resulting crop harvested December 8, 1914. The aerated plat yielded 83.5 pounds of rice paddy as compared with 71.5 pounds on the nonaerated portion.

A second test, to serve as a check upon the first, was conducted on the same plats. However, the order of the plowing was reversed, the aerated plat of the first test serving as a check plat under the second test. Owing to the late maturity of the previous crops, the aerated plat had but 30 days over the check plat. Both plats were planted to rice on February 18. Here again the yield on the aerated

¹ For results of a study of the effects of aeration on ammonification and nitrification in Hawaiian soils see Hawaii Sta. Bul. 37 (1915).

plat was the greater, 96.25 pounds of rice paddy being harvested from the aerated plat and 78.5 pounds from the nonaerated one.

In the soil aeration tests with taro, the aerated plat was given a deep plowing on June 10, 1913, while the nonaerated plat was plowed on September 10, 1913. Both plats were planted with white taro September 14, 1913, and harvested after a period of 14 months. The results of this test showed a slight increase in the yield of taro and a reduction in the percentage of diseased corms which may be attributed to soil aeration.

These tests are but preliminary work on soil aeration. As the land has been found to be quite unsuitable for definite results, these tests, which were conducted in Nuuanu Valley, have now been transferred to a plat in Waiau, which has been known to be under cultivation of aquatic crops, rice and taro, for 25 years.

Some depression exists among the local rice growers owing to the fact that island-grown rice can hardly compete with the Texas-grown product. At this time many rice growers are hesitating in regard to the further planting of their lands to rice, the inclination being to plant partially to forage crops for maintenance of cattle and hogs. The need of a good system of rotation for this particular type of soil is manifest, and the problem will probably be solved with the cooperation of the more intelligent rice planters.

POTATOES.

Experiments with potatoes included variety, fertilizer, and spraying tests, but the exceedingly dry and hot weather conditions materially affected the results.

In a fertilizer and spraying test with Early Rose potatoes, involving 10 plats of one-twentieth of an acre each, only the 6 lower plats produced plants, the 4 upper plats receiving too small a share of the prevailing light rains to start the eyes properly. This observation was substantiated by actual moisture-content tests taken at a depth of 6 inches in the soils of the upper and lower plats. The soil of the upper plats showed 16 per cent water, while that of the lower plats showed 24 per cent.

The test of spraying with Bordeaux mixture and lime sulphur on Early Rose potatoes resulted in yields of 15 bushels for the check, 25.9 bushels for lime-sulphur spray, and 30.2 bushels per acre for the Bordeaux mixture.

LEGUMES.

Among the new legumes received for trial are three red clovers from Switzerland, Ladino, white clover, and white sweet clover (*Melilotus alba*). These were planted among other legumes on February 18,



FIG. 1.—ONIONS.



FIG. 2.—MILLET.

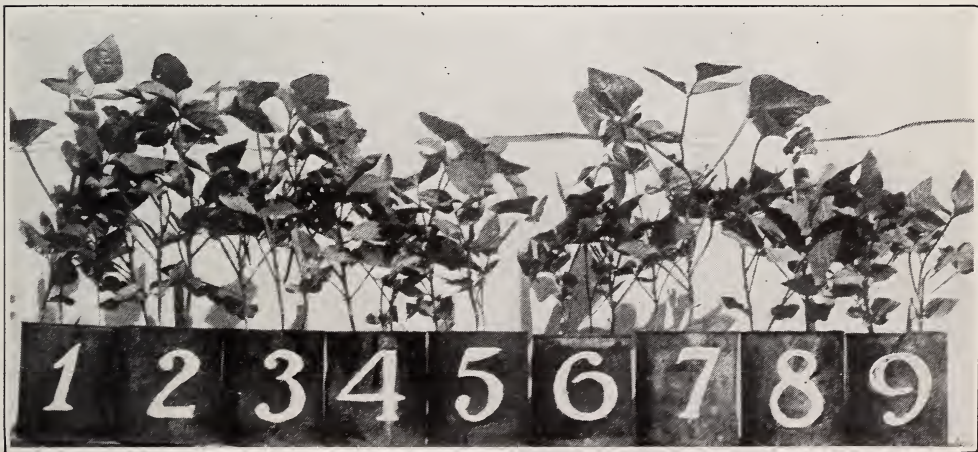


FIG. 3.—COWPEAS.

1, Check; 2, exposed to sunlight; 3, heated at 80°C .; 4, heated at 110°C .; 5, heated at 165°C .; 6, heated in autoclave; 7, treated with carbon bisulphid; 8, treated with chloroform; 9, treated with toluene.

EFFECT OF PARTIAL STERILIZATION OF SANDY SOIL ON PLANT GROWTH.



FIG. 1.—PLAT OF JAPANESE MILLET ON STATION GROUNDS.



FIG. 2.—PARTIAL VIEW OF SEED PRODUCTION TESTS OF LEGUMES VALUABLE FOR GREEN MANURE.

the three red clovers from Switzerland sending out their first blooms during the third week of June, when only a little over a foot in height. All the true clovers (*Trifolium* spp.) are recommended only for high, moist localities. The white sweet clover is very similar to alfalfa, though inclined to bloom considerably later.

Crotalaria mesopontica, introduced here in April, 1914, made a slow growth until fall, attaining a height of 2 feet during the winter months, in which period the plants produced profuse blooms and pods. Another species of *Crotalaria* (*C. madurensis*) from Ceylon, planted April 15, 1914, had already made considerable growth by July 1. Like the other *Crotalaria*s, this Ceylon variety is likely to earn a place among green-manuring crops for Hawaii. The two wild species of *Crotalaria* (*C. incana* and *C. striata*) have been planted in green-manuring tests, but fail to respond well to cultivation, the seed not germinating with the first rains, but beginning to appear some weeks later when the soil has become well settled.

In a series of sowings made with jack beans and species of velvet beans, seeds which were sown in early September made the most prolific yields of both green matter and seed. The jack bean, Yokohama bean (*Stizolobium hassjoo*), ashy pod bean (*S. cinereum*), and *S. capitatum*, matured in the middle of January. The Florida velvet bean and Mauritius bean matured one month later.

In a test for yields in forage of alfalfa under natural conditions of rainfall a Spanish alfalfa from Teneriffe and a Utah and Kansas strain of common alfalfa outyielded Peruvian and Turkestan. Given in the order of their merit, the yields in pounds of green forage per annum are: Spanish, 56,362; Kansas common, 52,065; Utah common, 45,245; Peruvian, 35,530; and Turkestan, 30,595.

Semipalatinsk alfalfa or Sholteek (*Medicago falcata*) failed to make a showing equal to that of the ordinary alfalfas or of Japan clover (*Lespedeza striata*).

SMALL GRAINS.

Further experiments with wheat, oats, rye, and barley show but small yields of grain under conditions similar to those on the station grounds. The season required from time of sowing to maturity is 5 to 6 months in duration; therefore the growth is too likely to be interrupted by long periods of drought for successful crops other than those for pasturing or green-manure purposes.

SORGHUMS.

The results of an experiment with a sweet sorghum, a non-saccharin sorghum, and Japanese cane for yields of forage over a period of 453 days were given in the last annual report. The total

yields per acre (green weight) for a period of 26½ months for the sorghum and 27 months for the Japanese cane are: Sweet sorghum, 8 cuttings, 86.55 tons; nonsaccharin sorghum, 6 cuttings, 88.45 tons; and Japanese cane, 3 cuttings, 157.64 tons.

Two other sorghums, African No. 307 (S. P. I. No. 25341) and a durra, No. 760 (S. P. I. No. 27878), have given splendid yields of forage, averaging 15 tons per acre per cutting at periods of 90 to 100 days. Of the sorghums under test for forage yields, Sugar Drip, milo maize, and feterita have shown a tendency to head out too early, or at least before putting out a large amount of leaf surface, the plants appearing weak and spindling. Kafir corn, while stronger growing than either milo maize or feterita, does not seem to show the drought resistance of Sugar Drip, Amber Cane, and the nonsaccharin, long-season African sorghums. Recent observations by the writer have brought to light an inclination among farmers to send to mainland seed firms for sorghum seed without specifying the type of sorghum wanted to supply their particular needs. The seed firms naturally fill such orders with their poorest sellers, usually a kafir or milo maize, which often fail, even with irrigation, to supply profitable yields of forage.

GRASSES.

Of the several forage grasses under trial, Sudan grass still maintains the lead which it gained soon after its introduction into this Territory by its prolific yields of succulent forage. In various tests this grass has yielded from 10 to 40 tons of green forage per cutting, still heavier yields resulting from ideal conditions of soil and rainfall being recorded. Tunis grass has proved valuable as a forage grass at high elevations. In comparison with Sudan at a low elevation, Tunis grass yielded an average of a little less than 4 tons per cutting per acre for six cuttings, while Sudan yielded an average of 14½ tons per cutting per acre for seven cuttings.

Molasses grass (*Melinis minutiflora*) has gained considerable favor in the Hamakua district of Hawaii. The farmers of that district prefer the molasses grass to either Australian water grass or Para grass.

Wilder grass (*Andropogon* spp.), introduced into the Territory by Mr. G. P. Wilder in 1913, has produced excellent results where sown for pasturage. This grass is very slow in its early growth, the first blooms appearing about 120 days after germination. If used as a forage crop, Wilder grass should be cut immediately upon the appearance of the first flowering heads, because the long awns on the flowering glumes interfere with its use as forage. The station plat, planted with roots received from Mr. A. F. Judd in December, 1913,

was cut for seed in June and October, 1914, and in January, 1915, and on being cut for forage May 29, 1915, this plat yielded 11.25 tons of green forage per acre.

Australian blue grass (*Andropogon sericeus*) is another valuable pasture grass for the lowlands. Its habit of growth is very much the same as that of Wilder grass, but it is a little more erect and somewhat less leafy at the bottom. Two cuttings of this grass averaged 9.5 tons green fodder per cutting per acre.

Giant Bermuda grass has met with most requirements of the average ranger for both pasturage and forage. It is adapted to all elevations up to 4,000 feet. Cuttings of this grass set out in soft, moist soil make little headway until the soil has become thoroughly compact. When once started, its growth is persistent.

Teff, Mitchell grass, wallaby grass, side oat grama, Judd, and American buffalo grass (*Bulbilis dactyloides*) have continued to persist under unusual conditions of drought for nearly two years.

BUCKWHEAT,

Further tests with Japanese buckwheat and Silverhull buckwheat were carried out in Nuuanu Valley, where greater moisture and apparently cooler conditions resulted in heavier yields of buckwheat than were obtained in any trial on the station grounds. The Japanese buckwheat matures a week earlier than the Silverhull and yields about 25 per cent more grain.

JAPANESE MILLET.

Trials with Japanese millet, undertaken at various periods, resulted in very good yields of forage when cut green, and of roughage and seed when allowed to mature. (See Pl. IV, fig. 1.) If grown for soiling purposes, millet must be cut when the flowering heads first appear, which is usually about 60 days from planting. Millet matures in 80 to 100 days under ordinary conditions, and its best period for cutting for forage value is limited to 8 or 10 days. Yields of 12 tons of forage per acre when cut green, and 3 tons roughage and 30 bushels of seed per acre when left to mature, are the approximate yields of the station plantings. As a soiling crop, millet is planted to best advantage in November and December, and harvested in January and February, the cool-weather months when sorghum yields are low.

NUT GRASS CONTROL.

The best results in controlling the spread of Japanese nut grass have been accomplished so far by spraying with arsenite of soda. Advantage is gained by spraying when the nut grass is heading out,

thus killing the growth above the surface of the soil and causing the stem below the surface to rot. Spraying in single applications, however, will not kill the underground bulbs, and new shoots will again appear after a week or 10 days. Following each application of arsenite of soda, all dead growth is burned off as soon as it is sufficiently dry, thus leaving the ground bare of growth. The new shoots of nut grass are then more easily accessible to the spray. Persistent spraying at the proper time to prevent seeding may eventually sap the vitality of the underground bulbs, finally killing them.

Other methods of eradication under trial are cutting frequently at the surface and plowing with a disk plow. The results of these methods at this time are not conclusive.

COTTON.

That paying crops of Caravonica "wool" cotton can be grown in the Kona district in spite of the pink bollworm (*Gelechia gossypiella*) is indicated in the continual demand for cotton seed from the homesteaders of that district to extend their cotton fields.

Of the stand of Caravonica "wool" cotton planted on the station grounds in February, 1910, two rows have been retained to furnish data on longevity and yields. The average yield per tree per annum, when grown for four years, has been approximately 1 pound of lint. The rows are 10 feet apart, with the trees 10 feet apart in the row.

Small stands of Sea Island, Egyptian Yuma, and Upland cotton are maintained annually to supply selected seed for distribution.

SEED DISTRIBUTION.

There has been a demand chiefly for soiling and pasture and pasture crop seed, Sudan, Wilder, Australian blue, teff, Tunis, and Mitchell grass seed, while roots or cuttings of Giant Bermuda and some other grasses have been eagerly sought. In the distribution of all seed particular pains have been taken to supply the homesteader with seed of crops particularly suited to his needs and environment. No attempt has been made to supply seed of field or sweet corn other than for trial plantings. A number of the more promising legumes are being grown for seed for limited distribution to farmers for cooperation tests. (See Pl. IV, fig. 2.)

REPORT OF THE EXTENSION DIVISION.

By F. G. KRAUSS.

INAUGURATION OF THE WORK.

The present agricultural extension work of the station was definitely inaugurated in November, 1914, when the present superintendent was appointed to take charge of the work. This work was provided for by a special fund of \$5,000 added to the regular appropriation for the Hawaii Agricultural Experiment Station. Previous to this, the extension work of the station was confined largely to projects provided for by local appropriations by the Territorial legislature. Most of the substations which were of nonexperimental character were provided for in this way. It is hoped eventually to correlate all extension and demonstration work under one head.

Hawaii is peculiar in that it has no established diversified agriculture with its usually associated groups of small independent land holdings so familiar on the mainland. Many efforts have been made to homestead various tracts of the public lands of the Territory, but no examples of markedly successful small farm communities are existent. The reason has been twofold: The establishment of communities of farmers in sufficient numbers to insure their stability can not be hoped for until it has been demonstrated by actual test that a variety of crops other than the few main staples now grown can be produced economically on a commercial scale, and that, various crops having been so grown, a profitable market can be developed for their disposal.

The lack of organized effort is doubtless the chief reason why greater success has not been obtained in the past. The Hawaii Experiment Station, and through it a few scattered farmers, have demonstrated that a large variety of crops now imported from the mainland, as well as many of those peculiar to the Tropics, can be successfully grown throughout the islands. The newly created marketing division has proved that most of such products find a ready sale, either locally or on the mainland, if delivered regularly in good marketable condition and sufficient quantity. It is the object of the new agricultural extension division to correlate these facts and to make known these and various other facilities of the United States Department of Agriculture for the direct benefit of the farmers of

Hawaii. The success that will accrue from this movement will be measured in large part by the extent to which the farmer will co-operate with the extension division.

The establishment of the Glenwood and the Hilo substations on Hawaii, the Nahiku substation on Maui, the Waipio substation on Oahu, and the Homestead substation on Kauai, together with the marketing division in Honolulu, constituted the initial cooperative effort made to aid the farmer in realizing a more normal and profitable agriculture. The establishment of a demonstration farm in the midst of the Kuiaha-Pauwela homestead tract, near Haiku, on the Island of Maui, is the direct outgrowth of an organized effort of the homesteaders to obtain this Government cooperation for which the extension division was created. It may be said to have been born of economic necessity. A group of some forty American families have cast their lot in an agricultural venture which promised well because of its favorable location and the apparent assurance of a safe and profitable crop. The successful culture of pineapples had already been demonstrated. A flourishing canning establishment was running to full capacity, and what appeared to be satisfactory contracts were entered into by the homesteaders for the disposal of their fruit. The unprecedented rains of 1914 proved disastrous to a large part of the crop, and the slump in prices (due to the troubled conditions in Europe, together with the general overproduction from new acreages) brought home in a striking manner the uncertainties of a single-crop system. The older pineapple growers had already found that successive plantings of pineapples on the same ground invariably give declining yields, regardless of fertilization and any reasonable period of fallow thus far practiced. The demonstration farm at Haiku, Maui, has under way as one of its most important projects the working out of a cropping system, which shall consist of a rotation of crops that will be beneficial to the land and of immediate cash value as well. Fortunately three or four out of the many leguminous crops already tested out on a field scale are promising for use in rotation with pineapples, which crop, it is generally believed, will remain a staple in the locality in question.

MISCELLANEOUS DEMONSTRATIONS.

Next in importance to the work of general organization of the newly created extension division is the practical farm demonstration and cooperative marketing work recently inaugurated on the island of Maui, which is to be extended as rapidly as possible to all the islands of the group.

The principal farm demonstration work on Maui is being centered on two homestead units in the Kuiaha-Pauwela tract near Haiku. The main work in cooperative marketing which has been carried on in the Kula district is also being centralized at Haiku. The work has recently been broadened to include the whole of Maui, and the other islands of the group will be given attention as rapidly as the limited means at hand will permit.

In addition to the experimental and demonstration work being carried on at the demonstration farms in the Kuiaha-Pauwela homestead tract, four extensive cooperative experiments and demonstrations and a number of minor trials are now under way on the island of Maui. A number of additional projects have been planned for the coming fall months, chiefly in the Haiku and Kula districts of Maui.

At Kula a farmers' cooperative marketing association, with a membership of over 100, has been organized and considerable farm produce marketed through it.

On both the farming and marketing phases of the extension work, as well as on the educational side, many difficult and complex problems are offered for solution. It will be especially difficult here, as elsewhere, to organize the farmers for cooperative action. The average farmer of the islands is not a business man and has not yet learned the economy and efficiency to be derived from cooperating with his neighbors. The more popular publications of the United States Department of Agriculture have been given a wide circulation among the farmers of the Territory.

One of the most important undertakings that has been imposed upon the extension division is the working out, into practical demonstrations, of efficient cropping systems whereby the fertility of the lands now being devoted to pineapple growing may at least be maintained if not improved. A permanent agriculture can not be built up under the present systems of crop and soil management as practiced even by the most advanced pineapple growers. The customary successive plantings of pineapples on the same land have invariably produced diminishing yields, even when the land has been left to lie fallow for a number of years between plantings. While a few desultory attempts have been made at green manuring pineapple lands, no systematic experiments in practical crop rotations and green manuring have been recorded. There appears to be no valid reason why the well-established principles of soil management, as they apply to other crops, should not be applicable to pineapple culture. It will be the aim of the extension division to make practical applications of many of the improved methods worked out by the

Hawaii Experiment Station, which, because of lack of practical demonstration, have not been brought home to the farmers with sufficient force to induce their adoption.

Real extension work in agriculture can not long ignore agricultural education. Such education and training has only as yet been hinted at in Hawaii, while on the mainland this important phase of extension work is receiving most careful study. The majority of rural inhabitants can not attend agricultural high schools and colleges. For these the best possible educational advantages should be brought to the farms and homes.

DEMONSTRATION FARMS.

The main farm demonstration work on Maui is being centralized on two homestead units situated in the Kuiaha-Pauwela tract near Haiku. The two farms are representative of average conditions in the lower and middle section of the homestead tract and apparently of a large part of Maui.

The lower homestead is in the drier section of the Makawao region. The average rainfall is about 40 inches per annum. Climatically this section appears to be well adapted to diversified and intensive agriculture. This particular homestead was among the first to be settled upon, the original settler planting his first crop of pineapples in 1911. An excellent crop of fruit was harvested in 1913, but in the succeeding year many of the plants sickened, and the yield of fruit was greatly reduced in consequence. Owing to financial difficulties, the original settler abandoned the farm in the fall of 1914. It was taken over by the superintendent of extension for demonstration purposes in January, 1915. The crop for 1915, both from old and new plantings, was practically negligible. In the sheltered portions of the farm fine vegetables in considerable quantity were grown. Both bananas and papayas, though now growing without care, are of excellent quality. The pineapple fields, consisting of about 10 acres, were abandoned to weeds, as it was considered hopeless to restore them to profitable production. However, about 50 tons of pineapples weighing a little under 3 pounds each was produced.

Immediately upon taking possession of the lower homestead, a tract of 16 acres was cleared of brush, the main growth being heavy grass sod and young guava which had sprung up after 1½ years of abandonment. The land was then given 3 plowings, 6 disk harrowings, and 2 draggings at a cost of \$40 per acre for the tillage operations. This cost is on a basis of \$6 per day for a man, 3 good working mules, and implements. The first crops were planted on May 6 and the last on May 28, 1915. The following crops have been planted for demonstration purposes.



FIG. 1.—BEANS AND CORN INTERCROPPED, PINEAPPLES IN BACKGROUND, HAIKU DEMONSTRATION FARM.



FIG. 2.—PREPARING GROUND IN PINEAPPLE FIELD FOR DYNAMITING, HAIKU DEMONSTRATION FARM.



FIG. 1.—DETAILED VIEW OF HONOHONO, A VALUABLE SOILING CROP FOR DAIRY CATTLE, GLENWOOD SUBSTATION.



FIG. 2.—SILO AND GENERAL VIEW OF THE GROUNDS OF THE GLENWOOD SUBSTATION.

Crops grown on the lower demonstration farm.

Crops.	Number of varieties.	Method of culture.
Field corn and beans.....	4 each.	Intercropped.
Jack beans for seed.....	1	In rows 2½ and 5 feet apart.
Sunn hemp.....	1	In rows 2½ feet apart, 25 and 50 pounds seed per acre.
Soy beans.....	4	Inoculated and not inoculated.
Pineapples.....	1	Ordinary.
Do.....	1	To be plowed under and green manured.
Para grass.....	1	Broadcast.

The middle demonstration farm is a well-established homestead. The equipment in farm buildings, farm machinery, implements, work animals, etc., is among the best in the Kuiaha-Pauwela and Kuiaha-Kaupakuhua homestead tracts which surround it. Systematic plantings have been made each year since the homestead was settled in May, 1912. While the main crop has been pineapples, for which the lands are especially well adapted, a cropping scheme is in operation which includes a definite rotation system. The crops employed are shown in the following table:

Crops grown on the middle demonstration farm.

Crops.	Number of varieties.	Crops.	Number of varieties.
Pineapples, 1, 2, and 3 years old.....	1	Peanuts.....	4
Corn.....	2	Watermelon.....	4
Legumes.....	4	Artichokes.....	1
Potatoes.....	8	Field beans.....	2
Sweet potatoes.....	3	Forage grass.....	2

The young pineapple plantings are being subjected to intercroppings of dwarf field beans, as are also some of the plantings of corn. (See Pl. V, fig. 1.) The success of this demonstration has introduced the practice among a number of local pineapple growers. A series of fertilizer, tillage, and dynamiting experiments with pineapples is also under way. (See Pl. V, fig. 2.) All crops grown are under fertilizer, liming, and tillage experiments. Careful records are being kept of all farm operations, and it is expected that these data will prove valuable to prospective homesteaders.

COOPERATIVE EXPERIMENTS.

In April, 1915, a 6-acre, cooperative, green-manuring, and legume-rotation experiment with pineapples was entered into with the Haiku Fruit & Packing Co. A project was worked out whereby the influence

of green manuring and rotation over a period of five years can be determined. Four leguminous crops are under test. The company furnishes the land, labor, and seed, while the extension division gives general supervision when such becomes necessary. The work is being unusually well done by the company and valuable results are expected.

A private planter has requested the services of the extension division in carrying on cooperative experiments in dynamiting and in treating soils antiseptically in pineapple culture, the land, labor, and materials all being supplied by the owner, who is one of the most advanced planters in the district. Another pineapple planter, who is entering into the dairy business, is undertaking a cooperative forage-crop and pasture-grass experiment. Largely through the suggestion of the extension division, this same farmer has acquired a herd of pure-bred Jersey cattle.

Early in the spring, through the advice of the extension division, an acre of beans was planted by each of some 20 homesteaders and others. The crops from all these tracts have been harvested and nearly all have been thrashed and marketed. It is hoped that bean culture may in time become as important an industry in this region as it already is in Kula.

Fifty pounds of Sudan grass has been distributed in the district, mostly in 1 and 2 pound lots, for trial and report. One grower reports that but for his half-acre patch of Sudan grass he would have suffered materially for forage for his dairy herd.

Four different projects have been planned and three are under way for cooperative leguminous crop demonstrations. These will be located along the main road running through the Kuiaha-Pauwela homestead tract. The value of these legumes has already been demonstrated on the extension division farms. The most promising kinds are jack beans, velvet beans, sunn hemp, and cowpeas. These are valuable for green manuring and forage, as well as for their seed which is now beginning to be eagerly sought by the sugar plantations.

The cooperation of the Territorial office of public lands and the division of forestry has been secured, and it is hoped that newly opened homestead tracts throughout the islands may hereafter have at the outset whatever assistance the extension division may have to offer.

In the newly surveyed Makawao homestead, which is shortly to be opened for settlement, a homestead unit is to be set aside for agricultural demonstration under the supervision of the extension division. It is also planned to reserve wide tree belts as a protection against the excessive winds that prevail there. Mr. C. S. Judd, chief forester of the Territory, is to give this matter his personal attention.

REPORT OF THE GLENWOOD SUBSTATION.

By F. A. CLOWES.

During the year the work of the substation has been continued along lines similar to those indicated in previous reports. The most interesting features of the crop work are the use and value of honohono for a soiling crop, *Paspalum dilatatum* for pasture, and cane tops for silage. Excellent results have been secured with chicks kept according to approved methods, and a flock of 250 pullets has been raised and housed in colony houses designed from standard plans, but altered slightly to suit local conditions. Considerable extension work has been carried on with excellent results.

HONOHONO (*Commelina nudiflora*).

From May 1, 1914, till April 30, 1915, the yield of honohono from a plat 10 feet square, which was a representative part of the field, was weighed at each cutting. The total yield of green feed per acre, calculated from this plat, was 223.6 tons (Pl. VI, fig. 1).

Honohono is an extremely succulent feed, much relished by cattle. Cattle fatten and produce an abundance of milk when pastured where it is plentiful. A study of the records of one of the pioneer dairymen at Glenwood shows that during a 29-month period, at a time when honohono was abundant, his herd of 33 cows of mixed breed gave an average annual milk flow of 6,100 pounds of milk per cow. The highest 12-month record was 8,616 pounds, and the lowest was 3,092 pounds. One dairyman in the same region secured a yield of 11,000 pounds from a Holstein cow fed honohono. It is believed that the yield of green feed recorded at the substation is not exceptional. Calculated from analyses reported by the station,¹ a ton of green alfalfa would contain the same amount of protein as 4.7 tons of honohono. Looked at in another way, 223.6 tons of honohono, the yield of 1 acre, would contain the same amount of protein as 47.6 tons of green alfalfa, which would be considered an exceptional yield from an acre in one year. For the food constituents other than protein, the comparison is even more favorable to honohono. To cultivate honohono, an abundant supply of manure

¹ Hawaii Sta. Bul. 13 (1906).

is necessary. This would be readily available were adequate provision made for the stabling of the cattle, as suggested elsewhere in this report. The cultivation of honohono as a soiling crop is proving very satisfactory in this region.

PASPALUM DILATATUM AS A PASTURE GRASS.

As a pasture grass, *Paspalum dilatatum* has given excellent results. Its strong deep root system enables it to withstand the tramping of stock in wet weather better than any other grass tested at Glenwood that is equally relished by the cattle. It has been extensively planted by local dairymen since its introduction by the substation. Both seed and divided roots have been used for planting. Homesteaders have been supplied liberally with roots from the fields of the substation.

CANE-TOP SILAGE.

The silo (see Pl. VI, fig. 2) was filled during June and July, 1914, with cane tops from neighboring fields. The weather during these months was excessively wet. The roof was not put on the silo till filling was almost completed, and as a consequence, much water found its way into the silo. The cane tops were bundled in the field and loaded on cane cars on the portable track used by the Olaa Sugar Co. in getting out the cane. The cars when loaded were hauled to a convenient place, and the tops were transferred to a wagon and hauled to the silo. Owing to various unavoidable interruptions, the silo filling was greatly delayed, and the silage was expensive. Some of the cane tops were cut two weeks before they were put into the silo. Notwithstanding the resulting staleness and the excessive amounts of water that went into the silo during filling, the silage was of fair quality and was eaten readily by the cattle and horses. To adapt the silo to profitable use for cane tops, it should be so located that there will be a minimum amount of labor in getting the cane tops into the silo. Since the economical use of the manure is a factor of controlling importance in any scheme for the use of considerable quantities of cane tops, the location of the silo and the feeding yard should be such that the manure can be supplied to the fields without too long a haul. The yield of cane tops per acre is about 10 per cent of the weight of the usable cane. On the unirrigated plantations this by-produce would run from 4 to 8 tons of cane tops per acre. These amounts are equivalent to about half the yield of corn silage secured by the live-stock farmers. A comparison of analyses of corn silage and cane-top silage indicates that the cane-top silage and corn silage are probably not greatly dissimilar in feeding value. This being so, it only remains to develop satisfactory practical

methods to produce, on every acre of cane land, a crop of beef, milk, or butter as a by-product of the sugar industry. This would ordinarily be equal to one-half of the main crop of the live-stock farmer elsewhere. In the feeding of silage to secure economical returns, supplementary grain feeding appears to be necessary. With judicious care of the manure, the fertilizing elements secured through the use of these grain feeds would replace much of the commercial fertilizer at present imported.

CATTLE.

During the year the station loaned the herd bull, Raymond of Alta Vista, to the Board of Commissioners of Agriculture and Forestry for four months, and he was placed by them at the Hilo Quarantine Station, where 15 cows were brought to him for service. This arrangement distributed his service over a large area without inconveniencing the Glenwood homesteaders to any extent.

The herd now consists of 1 registered Guernsey bull and 3 registered Guernsey cows, 1 registered yearling heifer, 2 registered heifer calves, and 2 unregistered Jersey cows. To adequately demonstrate the best methods of caring for cattle, the herd should be increased to 10 or 15 milking cows. Funds are not at present available for this purpose.

In the earlier part of the year, just previous to calving, one of the Guernsey cows, Kitchener's Vimera, was much troubled with sore feet, which, with the exposure to the heavy rains and the strain incident to parturition, kept her in very poor condition for several months. During wet seasons like the summer of 1914, the feet of cattle at pasture develop raw sores in the flesh between the divisions of the hoof. The horn on the inner surface of the hoof also becomes pitted and decayed, and the toes become sore. The horn of the hoof sometimes becomes much elongated, commonly reaching a foot in length unless trimmed. This lengthening is due to the absence of hard ground, which would ordinarily wear off the natural growth of hoof. The weight is then thrown back upon the rear of the hoof, thus adding to the other discomforts. Unless given attention, cows become so lame that they are unable to graze over a sufficient area while at pasture to keep them in good condition. By trimming off the surplus horn, by washing between the claws and applying antiseptics, and by keeping the animals out of the mud, cures are easily effected. Three of the cattle at the substation developed these troubles in the earlier part of the year before an extension of the stable made it possible to shelter all the stock.

When any considerable number of animals is affected their care becomes a serious burden unless adequate stabling is available to per-

mit of the animals resting on dry ground during heavy rains and at feeding times. The heavy rains, even when they do not cause sore feet, affect adversely the condition of the cattle, no matter how much they are fed, unless they can have adequate protection. On account of these facts outlay for stables and covered yards can be made a profitable investment. The value of the manure saved by providing concrete floors in these shelters would eventually repay the cost of the concrete construction. In July the station stable was extended to provide cover for all the stock.

FARMING OPERATIONS.

Throughout the whole region on the windward side of Hawaii and Maui the weather was so wet from the first of April to the end of September, 1914, that field work, with the exception of the unavoidable cane harvesting, was at a standstill. At the end of September, when the weather was comparatively clear and cultivation was possible, the fields were quickly restored to good condition, and little injury resulted to growing crops. In the cane fields effective results were obtained in weed control by the use of arsenite of soda on the dense growth. This destroyed at one spraying stands of weeds that would have taken several cultivations to subdue. At the substation no advantage could be taken of the good planting weather in the fall, since funds for the pay of labor were not available on account of the curtailment of the Territorial allotments. On this account no plantings were made from April, 1914, until April, 1915. Seasons such as that of 1914 occur only occasionally and do not prevent farming operations where the operators are not hampered by adverse circumstances other than the weather. Their occurrence does, however, point to the necessity of placing chief reliance on perennial crops such as the pasture grasses, Para grass, honohono, sugar cane, sorghum, and others that will undoubtedly come into favor with the greater use of cultivated crops in connection with the live-stock industry.

POULTRY.

The greatest drawback to poultry culture in Hawaii is the prevalence of a number of contagious diseases. Probably the most troublesome of these is sorehead.¹ It is very destructive to young chicks, but not to mature fowls. The method by which this disease is carried from fowl to fowl is not definitely known. Mosquitoes and insect parasites probably play an important part. The disease is most prevalent during the warm months from May to September. It has been the experience of many that early hatched chicks either escape

¹ Hawaii Sta. Press Bul. 46 (1914).

the disease altogether or recover from the attack. Incubator-hatched chicks, brooded artificially and kept from contact with other fowls, are less frequently affected than chickens brooded under hens. Chicks kept off the wet ground and properly cared for under cover till 6 or 8 weeks old are less frequently affected than those allowed on the ground at an earlier age. Well-fed chicks, given abundant exercise, are likewise less frequently troubled than neglected chicks.

There has been no contagious sickness among the birds at the substation. This is attributed to the fact that care has been taken to prevent contact with other birds. The houses are disinfected regularly, and the chicks are hatched early in the season. At the close of the breeding season in 1914 and before any of the chicks were put out of the chick pens, the breeding flock was disposed of, and the chicken houses were thoroughly cleaned and disinfected before placing the chicks in them. With the exception of three male birds, purchased for breeding purposes, the entire flock has been hatched in incubators and raised on the place, free from contact with other fowls. The roosts and dropping boards have been sprayed bimonthly with a mixture of 4 parts crude oil, 2 parts kerosene, and 1 part creolin. The houses are thoroughly cleaned annually and sprayed inside and out with the above mixture. As a result the birds have not been troubled with lice and mites, which in large measure explains the absence of disease. At the commencement of the fiscal year there were in the station flock 38 White Leghorn pullets and 12 Rhode Island Red pullets. One Rhode Island Red pullet was killed for examination. She was apparently healthy and fat but laid no eggs, although she entered the trap nest regularly. A post-mortem examination showed that the abdominal cavity was filled with soft-shelled eggs, flattened out, and occupying all the space not filled with the intestines and other abdominal organs.

Throughout the year the flock was fed on commercial scratch feed scattered in the litter during the day and in a hopper just before night. The total consumption by the flock for the 12 months was 1,800 pounds, which cost \$45, or 36 pounds per bird at a cost of 90 cents per bird. As the birds had free range, they picked up a large part of their living. During the year 4,204 eggs were produced. Part of the feed cost should be correctly chargeable to increase in the weight of the birds, but charging it all to the eggs, the cost per egg for the grain feed was 1.07 cents. The average wholesale price of eggs in Honolulu was about 43.5 cents per dozen, from which must be deducted the freight and marketing charges of about 5 cents per dozen.

Colony houses of four designs have been erected to determine their relative suitability. The design that seems most satisfactory is of the

shed-roofed type, 10 feet square, built of surfaced, tongued, and grooved northwest fir, with ceiling over the roosts for ventilation, built-in dry mash hopper, roosts for 50 birds, and 15 trap nests. The cost of each house was \$60. Allowing for 5 per cent depreciation and 5 per cent interest on the investment, the cost of housing per bird would be 12 cents per year.

EXTENSION WORK.

Through the month of July the superintendent of the substation was instructor in agriculture at the summer school for teachers under the auspices of the department of public instruction.

Through the suggestion of the substation, the cooperation of a number of civic organizations was secured for the holding of the first Hawaii County Fair at Hilo. The superintendent of the substation was the chairman of the managing committee of this fair. Great success met the effort expended in this attempt, and the fair is assured as an annual event. It has done much already to stimulate interest in poultry culture and the breeding of better live stock. Its influence on other branches of agricultural production is also considerable.

The boys of the Glenwood School have been given weekly instruction in milk testing at the schoolhouse and later at the substation. The work is now developing along the lines of cow-testing associations. The boys range in age from 8 to 15 years. The parents of each boy are directly engaged in butter making. The boys are much interested in the work and the accuracy of their testing is surprising.

The substation cooperated with the Hilo High School in the operation of a hatchery, and aided in the agricultural work by giving suggestions and advice. The substation supplied the hatchery with 100 dozen eggs for hatching, and loaned one incubator at the close of the season's hatching at the substation. Through the Hilo High School hatchery over 3,000 pure-bred, day-old chicks have been distributed. Where it was acceptable to the purchaser, advice was given as to the care of the chicks. This advice was naturally more frequently sought by school pupils than by adults. The system of care and feeding advocated was that outlined above as in use at the substation.

In every case where this system has been followed excellent results have been secured. Two cases of sorehead epidemic occurred among the chicks that had been distributed from the High School hatchery, but in both of these cases the chicks had been kept on the ground, contrary to the advice given. Sorehead was very prevalent in the town of Hilo during the months of April, May, and June, 1915. It is noteworthy that no cases occurred among the chicks sold from the hatchery and raised under cover and otherwise cared for according to

directions, including the feeding of dry mash and green feed from hoppers and scratch feed in deep litter. Poultry culture has been greatly stimulated by these efforts.

In recent years the methods of field cultivation on many of the sugar plantations have been greatly changed. At one time most of the field work was done by large gangs of coolies under the supervision of overseers. Gradually this method is being superseded in the interest of efficiency by cutting up the fields into smaller areas, which are leased to small planters.

Most of the plantations near Hilo plan to retain for cultivation by hired labor only sufficient land to profitably employ their labor force during the time the mill is not grinding. A great deal of the homesteading of the public lands has been done by citizens whose training has not been along the line of farming. Where the homesteads have not been sold shortly after being deeded to the homesteader, they are usually rented to the class of tenants that are leasing the lands of the large plantations. There has, therefore, developed a large class of tenant cane growers and a rural social problem, similar to that presented by farm tenancy elsewhere, but complicated by the one-crop system and the fact that the largest landlords, the plantation corporations, also control the cane market of the tenant.

These people, the homesteading landlords and homestead cane growers, have repeatedly appealed to the station for advice and assistance. This work did not fall directly within the scope of the station work, but such assistance has been rendered as seemed to be in accord with the general policy of the department.

HORTICULTURAL OBSERVATIONS IN PORTO RICO, CUBA, AND FLORIDA IN RELATION TO THE HORTICULTURE OF HAWAII.

By J. EDGAR HIGGINS.

In June, 1914, when the writer was about to close a year's leave of absence, instructions were received to report for duty in Porto Rico and proceed to Honolulu via Cuba and Florida, making observations of tropical horticulture en route. Considerable attention had already been given to the fruit industries of Porto Rico, and, after a week or more of further investigation, the steamer was taken, on June 29, direct to Havana. No attempt at an exhaustive study could be made, but much valuable comparative information was obtained, a part of which is recorded herewith, and much of which is on record for reference when required.

THE PINEAPPLE INDUSTRY IN PORTO RICO.

The pineapple industry of Porto Rico occupied during the year 1912 an area of 3,654 acres.¹ The output was valued at \$943,445, of which \$258,671 represents the value of the canned product and \$684,774 the value of the fresh fruit. Thus, less than 28 per cent of the total value of the crop was received for the canned product. The canning of pineapples, however, has been on the increase steadily, but has not increased so rapidly as has the export of fresh fruit, which in 1914 was valued at \$1,245,215. The proximity to great markets and comparatively frequent opportunities for shipping account for the more rapid development of the fresh-fruit industry. Steamers ply frequently between the island and New York.

The organization of the industry is quite different from that in Hawaii. There are practically no large corporations in Porto Rico. For the most part the holdings are small as compared with those of Hawaii. There are probably few, if any, individual or corporate holdings in excess of 250 acres. Pineapples are grown almost exclusively by Americans on farms or plantations. There are thus a good many growers interested in the business, but they are very widely separated, being scattered throughout the greater portion of the northern side and the western end of the island.

¹ War Dept. [U. S.], Ann. Rpt. Governor P. R., 12 (1912), p. 135.

CULTURAL METHODS.

As has already been indicated, the pineapple plantations are located chiefly along the northern side and western end of the island. These are all at comparatively low elevations, many being only slightly above sea level and none above a few hundred feet. They are nearly all served by the railroad which extends around the western end of the island from Ponce on the south to many miles east of San Juan on the north.

The soils on which pineapples are grown in Porto Rico are of several types, the sandy and sandy loam predominating along the northern side of the island, with some gravelly loam. Some clay loam, particularly on the western end, is devoted to the industry, and it resembles in appearance much of the pineapple soil of Hawaii. Some indications of manganese are found, but manganese does not appear to have given rise to much difficulty. Drainage is as vital a problem in Porto Rico as in Hawaii. Even the sandy soils are in many cases underlaid by a more or less impervious stratum which makes drainage difficult, particularly on lands with very slight grade.

Propagation methods do not differ materially from those in Hawaii, except that crowns are seldom if ever used. Slips and suckers are used almost entirely. With these is to be included the underground sucker which in Porto Rico is called a ratoon. Perhaps the reasons for the disuse of crowns are that the Red Spanish variety, which is the one most commonly grown, produces suckers abundantly; that these suckers produce fruit much more quickly than the crowns, and, further, that the Cabezona, which is the only other variety of importance, is extremely slow in producing a crop from crowns.

In preparation of the soil a long period of tillage is found necessary, as in Hawaii. The ridge system of planting is much in use, probably because it aids in quickly removing excessive water from the plants in a country where torrential rains are common. Flat planting, however, is seen in many places. About 12,000 to 14,000 plants per acre are set in case of Red Spanish, and various forms of arrangement are employed, some plantings being made as close as 12 by 12 inches in the beds or double rows. Much of the planting is done in the winter, the season of heavy cropping coming in the spring. Some progressive planters have found it possible and advisable to plant in July and thus distribute the season of cropping over a larger portion of the year, getting perhaps 75 per cent of the crop out of season or when there are few pineapples on the market and prices are good.

Pineapples are much used as an intercrop with citrus trees, and this combination, if carefully and wisely handled, sometimes results

in the pineapples practically paying for the establishment of the citrus orchard (Pl. VII, fig. 1). About two ratoon crops are generally taken whether the pineapples are grown exclusively or as an intercrop. Replanting does not usually follow immediately after the destruction of the first planting. It has been found necessary in Porto Rico, as in Hawaii, to prepare the land very thoroughly before the second planting. Where it is possible, fallowing for a year or more is frequently practiced, the land being used for pasture. In the destruction of the old plants, the ever-present machete is very much in evidence. This swordlike tool, which is used by the natives for almost every conceivable purpose in gardening, is very effective in cutting down the old plants. If the growth is dry enough after weeds have been allowed to grow it is sometimes burned over.

The cost of production of pineapples in Porto Rico is apparently about the same as in Hawaii. Pineapple lands, unplanted, cost from \$75 to \$250, the price being determined to a large extent by location. Labor can be secured at 62 cents per day, but because of the larger proportion of handwork and possibly lower efficiency, the planter's labor bill is probably not less in Port Rico than in Hawaii. The yield of pineapples ranges from 10 to 14 tons per acre. Fertilizers are used rather freely and with profit to the grower.

The varieties of most importance have already been mentioned. It is estimated that probably 90 per cent of the crop is Red Spanish. This variety is known to most growers in the Territory of Hawaii, although it has never proved popular here except in the Kona district of the Island of Hawaii. It is a vigorous grower and yields freely. The fruits are of small size, ranging from $1\frac{1}{2}$ to $4\frac{1}{2}$ pounds. They are of good quality, ship excellently, and sell well on the market. They are better adapted to fresh-fruit trade than to canning, because of their small size, which makes it impossible to get a large percentage of slices of sufficient diameter to pack the highest grade of canned fruit. They are, however, much used in canning. The Cabezona is an extremely large fruit, averaging from 8 to 10 pounds, 15 pounds being not uncommon, while fruits weighing 18 to 25 pounds have been reported. This variety has been grown in one locality in Porto Rico since the early part of the nineteenth century and has come to be known in some other parts of the world as the variety Porto Rico. Its origin in the island is not known. It seems well adapted to local conditions, particularly on the loamy soils, and is planted in those parts of the island where canning is being chiefly practiced, since it is not well adapted to the fresh-fruit trade. The Smooth Cayenne variety, upon which the Hawaiian industry is based, is almost never grown in Porto Rico. Many other varieties have been introduced, including the hybrids originated by the United

States Department of Agriculture, but up to the present time none have proved popular for commercial cultivation except the two named above.

DISEASES AND INSECTS.

The diseases of the pineapple in Porto Rico are not materially different from those of Hawaii. Soft rot, due to the fungus *Thielaviopsis paradoxa*, is more or less destructive to fruits in transit, but the Red Spanish variety shows considerable resistance, and by proper care in curing, packing, and transportation this trouble can be rendered unimportant. Base rot, due to the same fungus, is somewhat in evidence, but in the warm soils, if drainage is provided, it does not cause much loss. Leaf spot, also due to this fungus, is found chiefly in the coolest part of the year and in wet weather. Sun scald, following the bending over of the fruit, occurs as in Hawaii, but because of the small size of the fruits and the close planting, the loss is small in the Red Spanish variety. The practice has been followed to some extent of covering these exposed fruits with a little dried grass, the work being performed by children. Pineapple wilt occurs, but usually only where the conditions are unfavorable.

Perhaps the chief insect enemy of the pineapple in Porto Rico is the mealy bug (*Pseudococcus bromeliæ*) which is so common in Hawaii. It is accompanied by ants, which aid in its distribution. When the necessity arises, this insect is held in check by means of sprays. The pineapple scale (*Diaspis bromeliæ*) was not seen by the writer in Porto Rico and was said not to occur in the island.

MARKETING.

The fresh-fruit trade in pineapples from Porto Rico is exclusively with New York as a distributing center, except for a few small shipments which may go to New Orleans. The fruits are shipped in the Florida or Red Spanish crate. The dimensions of this are 10½ by 12½ inches inside measurement and 36 inches long outside. This crate is well suited to the Red Spanish variety. It contains from 70 to 75 pounds of fruit, net weight, averaging about 72 pounds. There are from 14 to 60 fruits in a crate. There are few that run so large as 14's, and very few so small as 60's are shipped. The sizes and approximate corresponding weights are indicated in the table on page 63. The prices received for the fruit of late years have averaged about \$2.50 per crate for the sizes ordinarily shipped—that is, from 42's up.

Until 1910 the prices received were very much lower. Up to that time there was no thorough organization of the fresh-fruit trade.

Fruits were shipped by individuals on consignment, and the results were about as unsatisfactory as those generally brought about by this system. At that time the Porto Rico Fruit Exchange was organized, at first having a severe struggle for existence, but now being well established. This is an organization of growers. At first stock was sold to nongrowers, but at the present time a man must be a bona fide grower to secure stock. Each share bears one vote in the control of the organization, and no grower can now buy more than five shares. This organization now ships about 60 per cent of the fruit grown in Porto Rico for export. It is estimated that about 85 per cent of the growers are members of the organization, but because of the heavy shipments of a few comparatively large growers, who ship independently, less than 85 per cent of the fruit is controlled by the organization. The shipping of these larger growers, however, is organized on a business basis, so that it does not demoralize the market as is always done by a large number of small growers shipping to a distant market without organization. The exchange handles about \$600,000 worth of pineapples and citrus fruits per year, which is the product of between 200 and 250 shippers. Most of these shippers represent individuals or companies. There are only one or two local exchanges. The Porto Rico Fruit Exchange employs a representative to look after the shipping of its fruit in San Juan, and a dock superintendent in its employ receives the fruit in New York, examines it, and if necessary has it repacked. An office is also maintained near the fruit auction rooms in New York City. To these auction rooms samples of each brand in the shipments are taken, and from these samples the whole shipment is sold. Steamship companies segregate all brands, sizes, etc., on the wharf where the buyer takes charge of his fruit. By this system of organized marketing the fruit growers of Porto Rico have been able to bring up the standard of their pack, to purchase in large quantities packing material and fertilizers, and to raise the price from a point that barely covered the cost of production to a standard that makes a good profit in the industry.

CANNED PINEAPPLES.

There are about half a dozen or more plants engaged in the canning of pineapples in Porto Rico (Pl. VIII, fig. 1). Those at the western end of the island are putting up the Cabezona variety, which is being grown for canning purposes. They also can the Red Spanish, but this variety is put up chiefly near San Juan. The style of pack is somewhat different from that of Hawaii. Some of the canneries make

a specialty of fruit for confectioners' trade. For this purpose the pineapples are gathered before they are thoroughly ripe, and while the fruit is quite white in color. Some of it is put up without sirup. The small size of the Red Spanish, especially as the best of the fruit is likely to be shipped fresh, makes it impossible to put up a large percentage of the pack in the highest grade of sliced fruit. Many of the quite small fruits are used to put up crushed, grated, pie-grated, and other forms.

The prices which it is necessary to pay for fresh fruit are much higher than in Hawaii. The success of the fresh-fruit trade brings about this condition of affairs. The table below indicates the prices paid and the classification of the fruits.

Classification and prices paid in Porto Rico for Red Spanish pineapples for canning.

Size.	Approximate weight per fruit.	Range in price per ton.	
		1913	1914
	<i>Pounds.</i>		
14's.....	5.1	\$20 to \$25	\$24 to \$31
18's.....	4		
24's.....	3		
30's.....	2.4		
36's.....	2	10	12 to 15
42's.....	1.7		
48's.....	1.5		
54's.....	1.3	5	5 to 10
60's.....	1.2		

In some canning establishments a somewhat different method of classification has been followed, and in some instances fruits weighing less than 1.5 pounds are not accepted.

It will be seen that 30's, or fruits weighing 2.4 pounds each, are accepted as first grade, while 36's, 42's, and sometimes 48's go as second grade. Some of the canneries will accept 60's, or fruits weighing only 1.2 pounds each, at a reduced price. It will be noted that for the first grade of fruit in 1914 the prices paid were from \$24 to \$31 per ton. In some cases this fruit was delivered at the cannery and in other instances to the railroad, the buyer paying the freight. The second grade sold for from \$12 to \$15 per ton. These prices were considerably in advance of those of 1913, when first grade sold for \$20 to \$25 and second grade for \$10. In some instances all fruit from 48's to 14's was taken in 1913 at a uniform price of \$22 per ton.

It will be noted that these prices are higher than any that have been paid in the history of the canning industry in Hawaii, and they exhibit a strong upward tendency simultaneously with the complete demoralization of prices on fresh pineapples in Hawaii, where they

sold as low as \$5 per ton for first-grade fruit. No attempt is made here to explain this wide divergence in prices of raw material. The canned product from Porto Rico sells (at retail) at somewhat lower prices than that from Hawaii.

PINEAPPLES IN CUBA.

Cuba ships about a million and a quarter crates of pineapples per year, the size of the crate being the same as that used in Porto Rico. A striking contrast between the Porto Rican and Cuban industry lies in the fact that there are many small growers of pineapples among the Cubans themselves. The cultural methods are similar to those pursued in Porto Rico, and the soils likewise vary from sandy to loam. The Red Spanish is the predominating variety, but a few Cayenne are shipped, chiefly from the Isle of Pines. The Abachi (Abakka) is frequently found in the home markets and is popular because of its fine flavor and texture, as well as its attractive appearance. This is a conical-shaped fruit and has the striking character of ripening before the fruit has turned yellow. If kept, however, a very fine color appears before the fruit has become too ripe for use. This variety sells in the Havana market at higher prices than the Red Spanish.

Practically all the Cuban crop is shipped as fresh fruit except the portion which is so consumed at home. There is very little organization of the pineapple growers for marketing purposes, which results in low prices and demoralization of the markets. Much of the packing is also poorly done, without sufficient curing of the fruit, or care in its handling. Fruits are often brought from the field to the packing house in bulk on large bullock carts without springs (Pl. VIII, fig. 2), which, in itself, would cause enough bruises to account for the very heavy losses which are often sustained through decay in transit.

There appear to be large possibilities for the development of the pineapple industry in Cuba. The areas of available land at comparatively low prices, the proximity to the great markets of the United States, together with the location of the island with reference to the routes of travel to Europe, all are favorable to a large development. The cost of labor is higher than in Porto Rico.

PINEAPPLES IN FLORIDA.

The output of pineapples from Florida is quite variable. It has exceeded a million crates in a single year. During 1914 it is doubtful whether the shipments amounted to more than a quarter of a million crates. This shrinkage is to be accounted for by the severe frosts of the preceding winter. Florida appears to be so well adapted to



FIG. 1.—CITRUS ORCHARD WITH PINEAPPLE INTERPLANTING IN PORTO RICO.



FIG. 2.—VIEW IN A 20-ACRE AVOCADO ORCHARD IN FLORIDA.



FIG. 1.—A PINEAPPLE CANNERY NEAR SAN JUAN, PORTO RICO.



FIG. 2.—A BULLOCK WAGON DELIVERING PINEAPPLES IN BULK AT THE PACKING HOUSE IN CUBA.

other horticultural crops—such as grapefruit, oranges, and early vegetables—that the production of pineapples may not be greatly extended.

The pineapple industry of Florida is divided into comparatively small holdings, by far the larger portion of the crop being grown by individuals or small companies. Practically the entire output is shipped as fresh fruit, the canning trade being almost negligible in this State. Some of the pineapples shipped fresh from Florida, as well as from Cuba and Porto Rico, find their way into the canneries of the United States, notably in the neighborhood of Baltimore.

The pineapple area in Florida is confined chiefly to a comparatively narrow zone along the eastern coast line of the southern part of the State, centering about Fort Pierce. The soils are almost pure sand, with a small admixture of humus. These soils, when heavily fertilized, produce very fine crops of pineapples. The arrangement and spacing of plants is much the same as that described for Porto Rico. The bed system is quite frequently found.

The Red Spanish is almost the universal variety and seems well adapted to the soils and conditions of that region. The variety Abachi, mentioned above, is grown to some extent, and skillful shippers succeed in placing it safely in the northern markets, although it is much more susceptible to injury in transit than is the Red Spanish.

Among diseases and insects in Florida may be mentioned wilt and the pineapple scale and mealy bug. Wilt has been quite prevalent and has caused heavy losses. The means for controlling the mealy bug and scale are similar to those mentioned in the discussion of the Porto Rican industry. It was found that some growers were protecting their fruits from sun scald by covering them with small pieces of cotton or other rough material where they had broken over and were lying exposed to the sun.

The fruit is shipped in crates of the same size as those mentioned above and goes chiefly to the large eastern markets, but is sometimes found as far west as San Francisco. There is not the organization of pineapple growers for the marketing of the crop that is found in the case of the citrus growers of the State, who are well organized. Many of the pineapples are shipped through commercial firms in Jacksonville. Florida, although nearer the great markets, is said to have a disadvantage in freight rates, the charge, for example, being 48 cents per crate from Miami to Cincinnati, while from Havana to the same destination it is only 29 cents. The Florida fruit has a long haul by rail before it reaches the market, but it is packed and handled so much better than Cuban fruit that the profits have probably been greater in Florida than in Cuba.

SUMMARY OF OUTPUT OF FRESH PINEAPPLES IN COUNTRIES VISITED.

In round numbers the output of fresh pineapples in the countries visited may be summarized as follows:

	Crates.
Florida -----	600, 000
Cuba -----	1, 250, 000
Porto Rico -----	650, 000
Total -----	2, 500, 000

Estimated on a basis of 72 pounds per crate, the total crop would be about 90,000 tons. The output of Hawaii in the form of canned pineapple for 1914 was approximately 2,250,000 cases or about 90,000 tons. The fresh fruit export of Hawaii amounts to only a few thousand tons. Florida, Cuba, and Porto Rico sell as much fresh fruit as Hawaii sells in cans.

CITRUS FRUITS.

The citrus industries of Porto Rico are rapidly increasing in importance. The grapefruit has made the most rapid advance, increasing in value from a little over \$7,000 in 1907 to nearly \$752,000 in 1914, when it equaled the orange output and at the present rate of development will soon surpass it. Porto Rico seems to be peculiarly adapted to the growth of this fruit, the trees bearing abundantly and the fruits, when well grown, being equal in quality to any of those with which they come into competition and superior to many. The business is as yet young, and although handled in a modern manner, many advances in methods of cultivation and marketing will doubtless be made.

Oranges grow on almost every finca, or farm, where they have been planted for coffee shade or for fruit production, but have received, in many cases, little or no attention. These are the seedling oranges which are in the local markets during a large part of the year, coming first from the lowlands and later from the altura, or high country. Late in the winter these fruits become well colored and are excellent for domestic consumption. Considerable shipments of these are also made to the United States, where in seasons of high prices they bring enough to pay a small profit to the shipper. The methods of handling these oranges, however, are far from satisfactory, since the growers are wholly unfamiliar with commercial methods of culture, handling, and packing.

Probably the larger part of the oranges shipped from Porto Rico is grown in orchards and handled in as modern a manner as could be expected in the early stages of the development of the industry. These orchards, budded to commercial varieties, are owned and con-

trolled by Americans almost exclusively. The Porto Ricans themselves have not adopted this type of cultivation.

The lemon is not produced in Porto Rico to any considerable extent, although there are some trial plantings on the south side of the island. The orchards of oranges and grapefruit just referred to are along the north side of the island in much the same localities as the pineapple.

In methods of cultivation there are some other points which are worthy of notice. The use of cover crops is notably on the increase, the jack bean (*Canavali ensiformis*) having proved of great value there, as it has in Hawaii. At most seasons of the year in the citrus districts there is an abundance of rain to maintain the trees, and the cover crop, which prevents the soil from washing, adds nitrogen, and maintains the supply of humus. In some cases grass has been allowed to grow under the trees, and some growers claim that the results have been very satisfactory.

The prevailing winds necessitate permanent and effective windbreaks, and one of the striking aspects of the landscape is the windbreak of bamboo about these orchards. Under Porto Rican conditions, the bamboo lends itself well to this use, making a rather thick mass of foliage through which the wind sifts slowly.

Porto Rico appears to have a comparatively easy task in the control of scale insects which add so much to the expense of citrus culture in many parts of the world. Nearly all the common scale insects of citrus are found in the island, but most of them are held well in check by fungi. The red fungus (*Sphaerostilbe coccophila*), the gray fungus (*Ophionectria coccicola*), and several species of black fungi are found to hold the scales under control. The relation of windbreaks to the control of insects by fungi is important. In exposed places, the fungi do not prosper sufficiently to be an effective means of control. The windbreaks, therefore, serve a double purpose in protecting the trees from wind injury and in assisting the warfare against insects. It is not generally found necessary to distribute these fungi by spraying or other artificial means. The attempt is being made to introduce these beneficial fungi into Hawaii. It is not to be expected that they will prove as effective in the dry climate of Honolulu, but in many humid localities, such as Hilo, Puna, and the Kona district of Hawaii, it is not improbable that these fungi would be a great aid in controlling the purple scale and the Florida red scale, which are so prevalent in these islands.

Aleyrodes howardi, related to the white fly (*A. citri*) which has given so much trouble to the citrus growers of Florida, is found in Porto Rico and is said to be a native species. It affects the orange, as well as a long list of other plants, but is not of so much economic importance, probably on account of its being parasitized by a hymenop-

terous insect not yet identified. *Pseudococcus citri* is said to be held well in control by the Australian species of ladybird (*Cryptolæmus montrouzieri*).

In Cuba the brevity of the visit made it impossible to do more than take a passing glance at the citrus development which has taken place in recent years. There are a great many small citrus holdings and a number of very large plantations of oranges and grapefruit, considerable American capital having been invested in that island. There is a large local consumption of oranges, many of these being shipped to the markets of Havana and the other large cities of the island. The larger part, however, is shipped to the United States. Because of the almost unlimited extent of land available at comparatively low prices, and because of the proximity to the American markets, there appears to be opportunity for much greater development. Many citrus orchards, however, have been planted and abandoned for one cause or another. Some of these have been on land unsuitable for their culture.

A striking feature in some of the Cuban citrus groves was the presence of grass, which has also been mentioned as having been found, but to a less degree, in Porto Rico. Many growers of citrus trees in Cuba claim that they have obtained better results by this method than by any other which has been tried. Whether a thorough test of leguminous cover crops has been made was not determined.

Scale insects are controlled by the same means as in Porto Rico. In all places visited, fumigation was never practiced, and spraying was used chiefly as a means of controlling the rust mite. This pest is very common and injures a large amount of fruit, which, although not affected in quality, is so badly injured in appearance as to seriously reduce the price. By means of the usual sprays, notably sulphur, the injury can be kept down to negligible proportions.

An orchard wagon of American manufacture seen in Cuba is worthy of mention as being possibly adapted to use in the pineapple fields of Hawaii. The peculiarity of this wagon is that the rear wheels follow exactly in the track of the front wheels. This prevents injury to many plants because not a few drivers who are able to drive well enough to get the front wheels away from the plants, run over them with the rear wheels of the ordinary wagon. Some of the pineapple growers of Hawaii are interested in further investigation of this type of wagon.

The citrus industries of Florida are older and more highly organized than those of Porto Rico and Cuba. The brief visit in this State permitted only a glance at a small part of the industry. Some of the matters which have been mentioned in connection with the citrus industries in Cuba and Porto Rico also impressed themselves

here. The efficiency of the parasitic fungi on some of the citrus scales was apparent. This, together with spraying for certain scales and for the rust mite, has resulted in very clean, bright fruit in many of the groves.

The highly organized system for the marketing of citrus fruits is worthy of special note. The Florida Citrus Exchange handles approximately 25 per cent of the output. The estimated crop for the 1914-15 season was about 7,000,000 boxes, of which the Florida Citrus Exchange probably handled from 1,500,000 to 2,000,000 boxes. This is an organization of producers and has done much to systematize marketing and bring satisfactory returns to the grower. The details of its organization can not be gone into here.

One of the most talked of subjects in citrus circles at the time of the visit was the citrus canker, a disease which had recently made its appearance in two widely separated parts of the State, one area of infestation being in the southern part, in Dade County, and the other in the extreme north, at Monticello, quite close to the Georgia line. This disease affects the foliage, the branches, and the fruits of several species of citrus, being notably a pest of the grapefruit, for the excellence of which Florida has become famous. This disease, which has also been found in most of the Gulf States where citrus is grown, appears to be very difficult of control. The energetic manner in which the growers and the Government are attempting to eradicate the disease from Florida is noteworthy. The warfare has passed from the stage of spraying and even of cutting down whole orchards to the use of an oil-burning torch especially constructed for the purpose. It was found that by the cutting down of the trees the operators themselves spread the disease. The torch is now applied without the operators coming in contact with the trees. So vigorous is the warfare that every tree that shows the slightest infection is burned to the surface of the ground. The soil also is treated in like manner. Whatever may be the outcome of the struggle, no efforts are being spared to rid the State of this serious disease.

The overhead systems of irrigation which have been installed in some citrus orchards attract attention. These have proved valuable not only as a means of supplying the trees with water but also in fighting frosts. The application of an artificial shower to the trees is a very decided protection during cold nights. Many growers feel that the system is worth all that it costs, either as a means of irrigation or protection against frosts.

Florida has been somewhat prolific in varieties of citrus fruits. A new orange, known as the Lue Gim Gong, which originated at De Land, is attracting much attention at the present time. Its special merit appears to be in its holding firm to the tree after it has

become ripe and well colored. It is said that it will hold on the tree for a year or more, enabling the grower to extend the shipping season for his fruit. It is described as "a late round orange of unusual merit."

Another of the originations of Florida now coming into some prominence is the Foster grapefruit, said to be a bud mutation from the variety Walters, which it very closely resembles in all particulars, except that the Foster has pink flesh, a new feature among the pomelos grown in the United States or the West Indies. Both of these varieties are now growing in Hawaii, and a limited supply of budwood will soon be available.

THE AVOCADO.

The avocado is claiming a place of considerable commercial importance in Florida and in California, but the West Indies do not appear to have awakened to the possibilities of profit in this unusual fruit. In Florida there are orchards of 25 to 30 acres, some of them now in bearing, while new plantings are constantly being made, particularly in the area along the east coast from Palm Beach southward (Pl. VII, fig. 2). The natural limitations of successful culture have not yet been determined, and there appears to be less tendency to emphasize the hardy varieties than in California. The avocado does not appear to be lacking in vigor and productivity in the parts of Florida referred to. This State possesses an unusual advantage in its proximity to great markets where its fruits can be placed about two days after picking, thus avoiding the need of refrigeration. The Trapp is the leading commercial variety and has many points in its favor, being in season when the markets are no longer glutted with northern fruits, and having a good form for packing and good keeping qualities. It is one of the easiest varieties to bud. The methods of budding are essentially the same as those which have been found adapted to conditions in Hawaii. In general practice, the bud is tied with only a waxed bandage which remains in place about 17 days, after which the bud is forced into growth by cutting back a few inches at the top of the stock and later removing its buds as they start into growth. There is a strong tendency to bud stocks in shingle boxes or other containers rather than in the nursery row, due in part to the Florida soils being not suited to the practice of lifting nursery plants with a ball of soil.

Porto Rico is rich in very excellent varieties of avocados, or aguacates, as they are known there and in other Spanish-speaking countries. The lack of effort to propagate by budding may be due in part to the high average of excellence among seedlings, but more probably to the fact that the commercial possibilities of this fruit

have not yet been recognized. With a three or four day service direct to New York, a season that could be made to cover nearly the entire year, varieties that need only to be sought out, standardized, and propagated by buds, and a climate in which the conditions are ideal and the danger of frost unknown, there appear to be opportunities that would appeal strongly to the enterprising fruit growers of California or Florida. The American fruit grower in Porto Rico is busy establishing his citrus and pineapple industries, which are yet young, and the native Porto Rican has not taken very enthusiastically to any line of fruit production.

Porto Rico doubtless has some varieties worthy of introduction into Hawaii, particularly choice early and late sorts to lengthen the season. This could be done at the present time by searching out the seedling trees, but when Porto Rican varieties have become standardized, it will be an easy matter to make the introductions by means of budwood which may be safely carried through the mails.

In Cuba, the price of avocados in July was a striking feature. Good-sized fruits were selling in Havana at 20 to 25 cents Spanish money,¹ and exceptionally good fruits are said to bring 10 cents each even in the height of the season. In the country districts, it was found necessary to pay 5 cents each for ordinarily good fruits in July, which, while not mid season, can not be regarded as out of season. It is said that they become quite cheap for a short time when they are most abundant.

There appears to be very little commercial culture of the avocado in Cuba, but interest in it is beginning to be aroused. The very large consumption of the fruit in Havana itself and the proximity to the American markets, with direct and frequent transportation, would seem to indicate that there are possibilities in the culture of the avocado here which will grow in importance as the fruit comes to be more widely known and used.

California is probably planting avocados more rapidly than any other country at the present time, plantings being made in different localities from San Diego to Butte County. In this State much emphasis is being placed upon hardy varieties, some of which are claimed to endure as much cold as the orange. These have been introduced chiefly from the highlands of Mexico. Some seedlings from Hawaiian stock were considered hardy under ordinary conditions, but many of these were unable to endure the severe cold of the season of 1912-13, when they were killed to the ground in the nursery.

In California budding in the open nursery is growing in favor, and in the heavier soils of this State it is possible to "ball" the trees

¹ The Spanish dollar has a purchasing power of something over 90 cents American money.

for transplanting. Many new varieties are being described and propagated, and there is considerable diversity of opinion as to which of these varieties are likely to take permanent places in the avocado culture of the State.

Concerning the insects and diseases of the avocado in the countries visited, some facts were noted. The avocado mealy bug (*Pseudococcus nipa*) was found in a city park in Mayaguez, Porto Rico, but was not seen elsewhere, and so far as could be determined, it had not been reported in the entomological records of the island, which would make it appear to be a comparatively recent introduction. The same species was found in one of the orchards in south Florida, but elsewhere was not seen, and appeared to be unknown to avocado growers, indicating that it is probably a recent introduction in Florida also.

No avocado borer (*Xyleborus* sp.) was seen or reported in any of the countries visited. The larva of an insect, locally known in Cuba as the bagworm, is said to eat the foliage of the trees. It is not reported as a very serious pest. Red spiders appear to be generally distributed and do slight injury, as in Hawaii. A disease first affecting the roots but later involving the trunk also, was reported in Cuba and was said to be somewhat serious. It was not seen and its identity has not been learned.

THE MANGO.

The mango has been planted on a commercial scale by at least one company in Porto Rico. The trees are vigorous and some varieties bear abundantly. The problem of determining the varieties best suited to local conditions is now being worked out. These have to be selected with reference to several factors, notably, varietal resistance to the mango fruit fly and to the mango blight. The mango fly (*Anastrepha fraterculus*) is similar in habit to the Mediterranean fruit fly, with which every one in Hawaii is now familiar. Varieties show marked differences in resistance. The Sandersha, for example, which is one of the largest and finest in appearance, as well as a most prolific bearer, is also one of the most susceptible to the fly.

The mango blight (*Glæosporium mangiferae*) is prevalent in the moister parts of Porto Rico, as in Hawaii, but some varieties are quite resistant. On the dry side of the island, with irrigation, this disease would do practically no injury.

One of the most promising varieties in Porto Rico is Amini, of East Indian origin. It very closely resembles Pirie, is said to be free from the attacks of the fly, and grafts readily on the native stock.

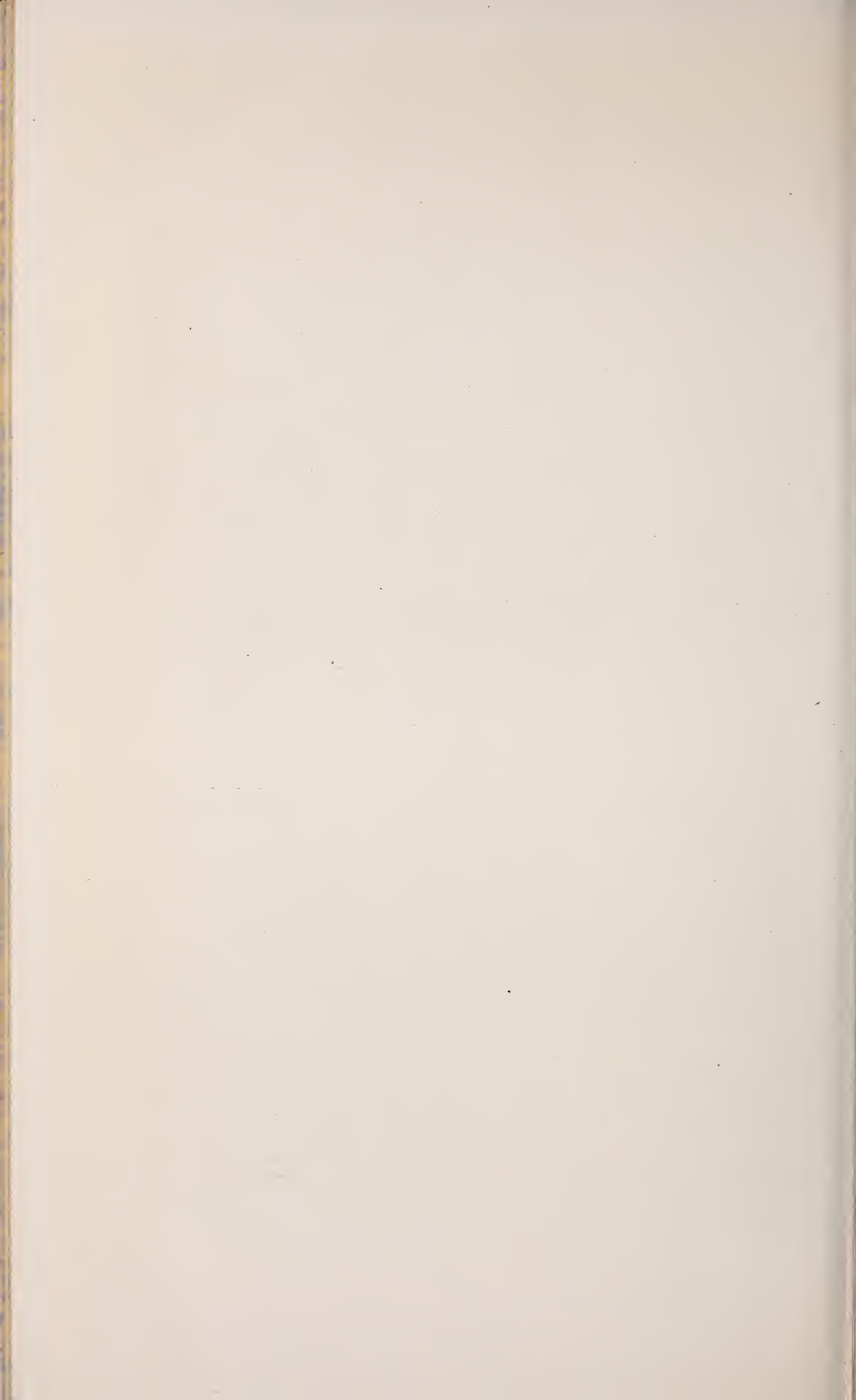
Piña (pineapple) is one of the so-called native varieties and is worthy of some attention. It has very little fiber, is of good flavor, and is quite resistant to the mango fly.



FIG. 1.—CRATES OF MANGOES AS THEY ARE PACKED IN FLORIDA.
Note the three different sizes of crates.



FIG. 2.—A TREE TOP-WORKED TO THE HADEN MANGO.



Hueva del Toro is one of the most common of the Porto Rican mangoes. It is of good appearance and fair flavor, but is somewhat fibrous and extremely subject to the attacks of the fly. It is very similar to the Hawaiian sweet mango.

In addition to several varieties of mangoes that have been introduced by the United States Department of Agriculture, three East Indian varieties have been introduced by the Misses Leitch, of Garrochales, who are making every effort to establish the mango on a commercial basis in Porto Rico. The varieties are known as Champaddan, Colombo Kidney, and Ceylon Horse House. The Colombo Kidney was seen and tasted and proved to be of excellent flavor and very fine texture.

A method of bark grafting the mango has been devised by the Porto Rico Experiment Station and is now being used by a number of fruit growers. This method has been found well adapted to Hawaiian conditions. (See p. 22.)

In Cuba there are a few commercial plantings of the mango and many of the East Indian varieties are being tested. Among the established forms that have long been in the islands, it is interesting to note the points of relationship to those of Hawaii. The variety known in Cuba as Manila is very similar to, if not identical with, that known in Hawaii as Pointed Chutney. It is of delicious subacid flavor and is free from fiber. The Seda is the same as that known in Hawaii as the No. 9, of which there are several forms all tending to the "S" shape and all of mild flavor and rather fibrous texture. Criollo closely resembles the variety in Hawaii known as the Double-Pointed Manila.

Florida has made substantial progress in establishing a mango industry, and small commercial shipments are being made regularly in season. (Pl. IX, fig. 1.) Budding is done in the nursery row and also in pots, and many varieties are being tested. The Mulgoba has been more generally planted than any other and is certainly a very fine mango as grown in Florida, where it acquires a good color. It is said to be a somewhat uncertain bearer, and growers are hoping for much from its seedling, the Haden, which is just now attracting attention and gives promise of being a heavier and more regular bearer (Pl. IX, fig. 2).

The establishment of the mango on a commercial basis is necessarily a slow process, but there can be no doubt of the ultimate outcome in countries adapted to its culture and able to ship the fruits to large markets. The best mangoes appeal to the average taste and are most attractive in appearance.

